Advisory Circular

U.S. Department
of Transportation

Federal Aviation Administration

Subject: AUTOMATED WEATHER OBSERVING SYSTEMS (AWOS) FOR NON-FEDERAL APPLICATIONS

Date: 11/13/95
Initiated by: AND-430

AC No: 150/5220-16B
Change:

1. PURPOSE. This advisory circular (AC) contains the Federal Aviation Administration (FAA) standard for non-Federal Automated Weather Observing Systems (AWOS).

2. CANCELLATION. AC 150/5220-16A, Automated Weather Observing Systems (AWOS) for Non-Federal Applications, dated 6/12/90, is canceled.

3. DEFINITION An AWOS is a computerized system that automatically measures one or more weather parameters, analyzes the data, prepares a weather observation that consists of the parameter(s) measured, and broadcasts the observation to the pilot using an integral very high frequency (VHF) radio or an existing navigational aid (NAVAID).

4. APPLICATION. The provisions of this Advisory Circular (AC) are effective immediately for all systems, or portions thereof, that are submitted for type certification or for previously type-certified systems that are submitted for modification of their type certification certificate. An AWOS that has been manufactured, installed, and maintained according to the criteria in this AC constitutes a National Weather Service (NWS) approved source for weather information; is approvable as a source of weather information that partially satisfies Federal Aviation Regulations (FAR); may be eligible to receive a broadcast frequency assignment or broadcast over a NAVAID; may be eligible to distribute its weather over the national weather network; and may be eligible-for funding under federal grant programs.

5. CONTENT OF THIS AC. ngly, this AC provides guidance about the program elements that should be incorporated into an AWOS in the National Airspace System (NAS). Itprovides the guidance and suggestions for one method, but not the only method, of complying with all pertinent regulations.

6. PRINCIPAL CHANGES. Adds that FAA is committed to adoption of a version of the METAR format. Adds the requirement for the AWOS maintenance technician to comply with the qualification requirements in most recent version of Order 6700.20A (Non-Federal Navigational Aids and Air Traffic Control Facilities). Adds the requirement for VHF and ultra-high frequency (UHF) radio parameters to be added to the maintenance manual. Adds that AWOS manufacturers are encouraged to design their systems in accordance with FAA Standards 019 and 020 and the National Electrical Code, and to be

installed in accordance with local codes. Corrects the specification for the reference visible light transmissiometer standard. Adds the requirement for a SO-second manual voice message at towered locations. Modifies the requirement for periodic data validation. Corrects a number of editorial errors and administrative oversights. Significant changes are annotated with a vertical line at the left of the text.

7. <u>REQUESTS FOR INFORMATION.</u> Further information concerning AWOS standards and the FAA type-approval process may be obtained from the AWOS program office at the Federal Aviation Administration, 800 Independence Avenue, Southwest, Washington, DC 20591 Attention.: AWOS Program Office, AND-400, Telephone (202) 267-3066.

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CHAPTER 1. INTRODUCTION

1. <u>FUNCTIONAL DESCRIPTION</u>. An Automated Weather Observing System (AWOS) automatically measures meteorological parameters, reduces and analyzes the data via computer, and broadcasts weather reports which can be received on aircraft radios. Pilots may use weather information provided by the AWOS to partially fulfill the requirements of various Federal Aviation Regulations (FAR). For example, at airports with instrument approaches, an AWOS weather report eliminates the remote altimeter penalty and thereby allows use of the published minimum descent altitude.

2. <u>WEATHER SENSORS</u>. The AWOS is a modular system utilizing a central processor which may receive input from several sensors. Five standard groups of sensors are defined in subparagraphs a.-e.; however, an AWOS may be certified with any combination of sensors. Depending upon system design, additional sensors may be certified to any AWOS configuration.

a. <u>AWOS A</u>. The AWOS A system contains only dual-pressure sensors that measure pressure and report altimeter setting to the pilot.

b. <u>AWOS I</u>. The AWOS I system contains the AWOS A sensors, plus sensors to measure wind data (speed, direction, and gusts), temperature, and dewpoint, and to report density altitude.

c. <u>AWOS II</u>. The AWOS II system contains the AWOS I sensors, plus a visibility sensor.

d. <u>AWOS III</u>. The AWOS III system contains all the AWOS II sensors, plus a cloud-height sensor.

e. <u>AWOS III P</u>. The AWOS III P system contains all the AWOS III sensors, plus a precipitation identification sensor.

f. <u>AWOS III T</u>. The AWOS III T system contains all the AWOS III sensors, and includes a thunderstorm/lightning reporting capability.

g. <u>AWOS III P/T</u>. The AWOS III P/T system contains all the AWOS III sensors, plus a precipitation identification sensor, and also includes a thunderstorm/lightning reporting capability.

h. <u>AWOS Iv</u>. The AWOS IV system contains all the AWOS III sensors, plus precipitation occurrence, type and accumulation; freezing rain; thunderstorm; and runway surface condition sensors.

3. OUTPUT MEDIA FOR AWOS WEATHER INFORMATION.

a. The output of the AWOS is reported by a computer-generated voice, which is transmitted to pilots over the voice output of a navigational aid (NAVAID) or via a discrete very high frequency (VHF) transmitter. The transmission may be continuous or may be a 3-minute broadcast triggered by three clicks of a pilot's microphone on the AWOS broadcast frequency (if the AWOS broadcasts over a VHF discrete frequency radio). System design may permit the transmission of the identification of a NAVAID by using the AWOS voice capability. In all cases where the voice output of a navigational aid is used, provision should be made so that the failure of an AWOS would in no way result in any failure of the NAVAID being used.

b. AWOS messages may be offered via other formats which the owner chooses to provide, including a telephone dial-up service. An option allows an AWOS III (or greater capability) to be linked to the national weather network so that the weather information is available nationally for forecasting and flight planning purposes. (Detailed requirements are in Order 7110.104, Non-Federal Automated Weather Observation System (AWOS) Connection to the Weather Message Switching Center (WMSC).) (AWOS sponsors may also obtain information regarding connection to the National Airspace Data Interchange Network (NADIN) from the regional non-Federal System Coordinator's office.) To contribute to this network, the AWOS should have an interface module which puts the data into a format which is compatible with the planned, centrally located AWOS Data Acquisition System (ADAS). An ADAS is to be located in each Air Route Traffic Control Center (ARTCC) and will collect and consolidate AWOS reports for input to the national network. The data communications protocol and other details of the interface between the AWOS and the ADAS may be obtained from the office listed on the front of this AC. Options to provide AWOS data directly into the Weather Message Switching Center (WMSC) using NADIN may be approved by the FAA. The sponsor of an AWOS that has been linked to the national weather network via either ADAS or NADIN would be required to sign a Memorandum of Agreement with the FAA Air Traffic Division in the applicable FAA region that commits them:

(1) to convert the AWOS data to the current or future ADAS format, when used with the ADAS interface.

(2) to the current or future Surface Aviation Observation format (SAO) to include a change from the SAO to the International Aviation Routine Weather Report (METAR) format (paragraph d), when used with the NADIN interface. (The FAA is committed to adoption of a version of the international METAR format.)

(3) to a reporting frequency (e.g., number of reports per hour) in accordance with criteria directed by the FAA, when used with the NADIN interface,

(4) to bear all communications, quality assurance, troubleshooting, and administrative costs to interconnect their AWOS to the ADAS or NADIN.

(5) to provide a focal point for use by the FAA and others to report problems with the AWOS or with the communications link to the ADAS or NADIN. (The focal point would be available by telephone and responsive during normal business hours, and is encouraged to be responsive on a 24-hour a day basis.)

c. The output of the AWOS weather observation is controlled by one of four modes of operation. Mode 1 is applicable to all systems; modes 2, 3, and 4 are applicable only to systems configured with an operator terminal (OT). Modes 3 and 4 require an agreement with the NWS to maintain a Supplementary Aviation Weather Reporting Station (SAWRS) capability for augmentation and backup.

(1) Mode 1, Full-time Automated Operation In this mode, the AWOS operates 24 hours/day without any manual input. The automated weather observations are updated on a minute-by-minute basis. There is no weather observer input to the AWOS. However, a manual observing capability may be maintained as backup provided that an agreement exists with the National Weather Service (NWS) to maintain a manual observing capability.

(2) Mode 2, Full-time Automated Operation with Local Notice to Airmen (NOTAM). Operation in this mode is the same as Mode 1, with the addition of the capability to append a manually recorded NOTAM to the automated voice reports [par 31a(1)(iv) and 32]. The airport manager is responsible for the NOTAM information. The NOTAM information is heard on the local voice broadcast; it is not transmitted longline. There is no weather observer input.

(3) Mode 3, Full-time Automated Operation with Manual Weather Augmentation and Local NOTAM Option. Operation in this mode provides the capability for a weather observer to manually augment the automated observation by appending a weather entry to the observation during the published weather observer duty hours. The observer duty hours should be published in the Airport/Facility Directory. The addition of a local NOTAM per subparagraph (2), is also permitted in this mode of operation, provided there is no interference with the observer augmentation. The weather observer is responsible for the accuracy and timeliness of the added weather information. The weather to be added is limited to thunderstorms, all types of precipitation, and obstructions to vision. The weather added by the observer is to be manually recorded and appended to the automated voice reports using the operator terminal (OT) microphone and, as applicable, entered manually (using the AWOS keyboard) into the system for transmission over the Service A teletype network. The procedures in Federal Meteorological Handbook No. 1 (FMH-1) and FAA Order 7900.5, Surface Weather Observing, apply.

(4) <u>Mode 4, Part-time Manual Operation</u> Operation in this mode is normally used for backup. Operation in this mode permits a weather observer to enter a complete manual observation into the system. The procedures in FMH-1 and Order 7900.5 apply to the recording and formatting of these manual observations. As applicable, the manual observations are transmitted over the Service A network. Voice dissemination of the observations should be done manually using the OT microphone. The manual observations include input from the automated AWOS outputs available to the weather observer on the OT display, to be modified to Order 7900.5 requirements. For example, the manual observation includes manually derived ceiling/sky condition and visibility using FMH-1 definitions, which differ somewhat from the AWOS algorithms. Temperature, dewpoint, wind direction/speed, and altimeter setting are the same and are used exactly as presented on the AWOS OT display. Sea-level pressure, if required to be included in the observation, is normally computed manually, since it is not an output included in the AWOS automated output.

d. <u>International Aviation Routine Weather Report Format (METAR).</u>

(1) The United States Government and the Federal Aviation Administration have committed to implementation of a version of the international aviation routine weather report (METAR) format. A date of January 1, 1996 has been established for the change from the current surface aviation observation (SAO) to the METAR format.

(2) All automated weather observing systems (AWOS) that are to be installed and commissioned after January 1, 1996 must have all outputs in the METAR format. Every AWOS must be type certified with this modified format. Each manufacturer offering to market such a system must submit a type certification request to the FAA in accordance with the procedures in this Advisroy Circular (AC) to demonstrate that their system outputs in the METAR format.

(3) All AWOS data output to the national, weather network on or after January 1, 1996 is to be in the METAR format. Systems commissioned prior to this date have two options for their output to the network: they may output in the METAR format, or they may have their SAO output converted to METAR at the processor, after which the observation is forwarded to the national network.

(4) All AWOS that are installed and commissioned prior to January 1, 1996 may continue to operate locally using the currently approved SAO format for the ground-to-air radio and the telephone. However, in the interest of standardization of aviation weather reporting, the conversion of the local output message to the METAR format is encouraged.

(5) An interface control document is currently under development. A current copy is available from the AWOS program office at the address listed on the front of this AC.

CHAPTER 2. CERTIFICATION AND COMMISSIONING PROCESS

4. PROCESS OVERVIEW. In order to provide confidence in the quality of the meteorological data which the AWOS provides to users in the aviation community, the Federal Aviation Administration (FAA) has initiated a three-part AWOS certification and commissioning process.

a. The manufacturer should provide the FAA with the test data and other documentation to demonstrate that the AWOS system meets the criteria of this AC (par 5, type approval). Upon completion of all the requirements set forth herein, the FAA grants type approval to the specific system that was documented in the request.

b. Prospective users should closely coordinate their plans with the regional non-Federal System Coordinator. After the AWOS is installed onsite, the FAA conducts an inspection to verify that the system is installed and operating correctly and that the owner has the resources to maintain the system in proper operating condition (par 11, facility commissioning). This process should be successfully completed for the AWOS to be commissioned by the FAA, and thus to be authorized to operate as part of the National Airspace System (NAS).

c. Finally, there may be visits to the operating AWOS by the FAA and other technical representatives to verify that the system continues to operate correctly (par 14, ongoing system validation).

5. SUBMITTALS BY MANUFACTURER FOR TYPE APPROVAL The FAA grants approval to an AWOS design after review and approval of three submittals from the manufacturer. The first submittal consists of test procedures and data sheets which demonstrate that the proposed AWOS configuration meets the hardware and software criteria of this AC. This submittal for type approval should include a single matrix showing each specific requirement from this AC, cross-referenced to the specific location (paragraph, page, etc.) within the manufacturer's submittal where the requirement has been addressed. The second submittal consists of warranty, training, and maintenance documents intended to support the AWOS system owner. The third submittal consists of a configuration control plan which identifies the components and options approved for use with the system. Requests for type approval should be sent to the AWOS program office at the address listed on the front of this AC. Product approval may be revoked (or an individual site may be removed from service) if:

a. The equipment has an unacceptable failure rate or outputs weather data that is not representative of actual weather conditions.

b. There is a deficiency that adversely affects safety of flight.

c. Changes are made in the equipment without FAA approval.

d. The manufacturer fails to honor the warranty.

6. UNACCEPTABLE FAILURE RATE;. Since reliable equipment is of prime importance to safety of aircraft operations, equipment which proves unreliable in use must be removed from the approval listing. The determination of unreliability must be based on judgment and experience with equipment of a like nature. Where any such equipment is deemed to have an unsatisfactory failure rate or is deficient in workmanship or materials, the manufacturer would be notified in writing as to the basis for this determination. The manufacturer should then notify the FAA in writing as to its plan of action for correcting the problem. If the manufacturer does not resolve the problem within a reasonable time (the timeframe would, of necessity, be based on safety considerations and/or the nature of the problem), the equipment would be removed from the approval listing. The FAA reserves the right to require the equipment to be resubjected to any or all qualification tests when the equipment has been deemed unreliable or deficient in design, materials, or workmanship. Owners of similar AWOS's should be notified of any problems uncovered during this retesting through the configuration control procedure discussed in paragraphs 9 and 14c.

7. TEST PROGRAM. Chapter 3 contains the performance and testing standards for each component of the AWOS. The manufacturer should demonstrate compliance with these standards through performance testing (where a test is specified) or by analysis and inspection. The manufacturer provides all necessary equipment and bears all testing costs. It is recommended that the manufacturer propose a test plan to the FAA containing detailed procedures for conducting the tests, as well as the name and location of the facility where the tests are to be conducted. Prior FAA review of the test plan should minimize the likelihood of improper test procedures which might result in rejection of the data. It is the responsibility of the manufacturer to provide test data to the FAA that is credible, factual, and representative of the equipment being certified. Submissions should include all data collected during a test; data should not be omitted because it falls outside of the recommended acceptable limits of this AC. After completion of the tests, the manufacturer should reduce the data to an easily understood format to demonstrate conformity with this AC. If the manufacturer has previously performed testing, the test procedures and data sheets from these tests may be submitted for FAA approval. However, the FAA reserves the right to witness testing and to examine raw data.

8. SYSTEM DOCUMENTATION. The documentation described in this paragraph should be submitted by the manufacturer to the FAA for review and approval. These documents are intended to assist the AWOS owner in installing, operating, and maintaining the system. They should be provided as separate manuals. The items may be cross-referenced to avoid duplication, but the elements of each portion of each document should be clear. (For example, the maintenance procedures which are performed during the annual system revalidation should be explicitly referenced.) After the FAA has approved the (a) system description, (b) maintenance manual, (c) installation and checkout manual, (d) operating instructions, and (e) annual system revalidation plan, 12 copies of these

approved documents should be submitted to the AWOS program office before type approval of any system (or any system modification requiring a change in any of these documents) would be granted. If the manufacturer wishes to modify the initially approved configuration, then the supporting documentation should be revised to reflect the approved change (and 12 copies of the approved documents should be submitted to the program office) before type approval is granted and the system is offered for sale.

a. System Description. The system description identifies and catalogs the hardware components to the'level of the smallest field-replaceable module and describes computer software. The principles of system operation are described using schematics, block diagrams, and flow diagrams. For peripheral devices, the performance parameters are included along with the name and address of the original manufacturer.

b. Manufacturer's Maintenance Manual. The manufacturer's maintenance manual should contain a comprehensive maintenance program to be implemented by the owner to ensure reliable and accurate performance over the life of the system. As a minimum, the program should define all maintenance activities which are required within a period of 5 years and a recommended frequency (e.g., quarterly, annually) for each operation. The following topics should be addressed in the maintenance manual.

(1) Maintenance Procedures. The manual should contain a step-by-step procedure for each scheduled (i.e., periodic) and unscheduled (i.e., repair) maintenance operation. It should discuss calibration methods, troubleshooting procedures, suggested spare parts, and should identify all test equipment required. This document should also include the detailed procedures (e.g., the keystrokes) followed by the maintenance technician when using the Operator Terminal to perform maintenance on the system.

(2) System Performance Parameters. The manual should contain a complete listing of the test points, sensor outputs, waveforms, and other parameters which indicate system performance and that may be measured in the field. If these quantities are field-adjustable, then an initial value (for use during initial certification) and an operating tolerance (for use during the annual verification) should be given. The key system parameters should also be identified; i.e., those values which best indicate system performance and to be checked most frequently. The frequency of scheduled maintenance actions (e.g., monthly, quarterly, annually) should also be given.

(3) Data Recording Forms The manual contains three forms designed to aid the system owner in recording the system performance data described in subparagraph (2). The Comprehensive Facility Performance and Adjustment Data form (similar to FAA form 6030-17) should be completed at system commissioning, and after major repair work (i.e., after a major component has been replaced). The form contains the standards and tolerances of each component, and also

contains space to record the performance of each. The Technical Performance Record (similar to FAA form 6000-8) is a checklist of all of the scheduled maintenance visits (e.g., monthly, quarterly, annual) to the facility. It also includes the standards and tolerances required to be measured (with a space to record each) during every scheduled visit. It is to be used to record the actions during the monthly and quarterly maintenance visit, the annual validation, when maintenance is performed on any individual component, and to log the validation procedures after an aviation accident. The third form is the Facility Maintenance Log (FAA form 6030-l). All site visits should be documented on this form. It provides a historical record of all maintenance actions accomplished on the AWOS. The technician should list all maintenance actions accomplished (e.g., "monthly periodic maintenance actions completed;" "dew point sensor replaced"); any damage should be logged (e.g., "bullet hole in vertical fin of the wind sensor, needs replacement"); any problem with the AWOS should be noted (e.g., "dew point sensor disconnected; replacement required"). When a system or component verification procedure has been accomplished, the maintenance technician should make such a note in this log. In all cases, each of these logs should be signed by the technician completing the action. These forms also contain the date of the action, the facility name and location, and other identifying data. They should be maintained in the Facility Reference Data File (FRDF, paragraph 12).

c. Installation and Checkout Manual This document should thoroughly describe the installation and checkout procedures to be followed by the technician at the installation site.

d. Operating Instructions (i.e., an Observer Handbook) Provides detailed instructions for a weather observer to operate the system. This document should describe and provide instructions for operation in each of the four modes (par 3c), and it should explain the procedures when using the Operator Terminal to augment or to back up the AWOS, or to disseminate NOTAM information.

e. Training Program. The training program should consist of a summary of the knowledge and skills which a maintenance technician should possess to service an AWOS. This document should also propose a program to familiarize maintenance technicians with the maintenance and operation of the AWOS system. The instruction program may be conducted onsite, at the factory, via home study, or by other means suggested by the manu-facturer. The training program should also contain standards for establishing the proficiency of and certifying potential maintenance technicians. These standards should contain a minimum of 100 questions (with answers) that may be used by the FAA to test the competence of the maintenance technician on the specific system being submitted to the FAA for approval.

f. Annual System Revaluation Plan. This plan should contain the recommended procedures to conduct an annual inspection of the facility in order to verify that it is in the approved configuration and operating within tolerance (par 14).

g. __Warranty__ The manufacturer should submit a statement certifying the following minimum warranty for the equipment:

"This equipment has been manufactured and should perform in accordance with requirements of FAA Advisory Circular 150/5220-16. Any defect in design, materials, or workmanship which may occur during proper and normal use during a period of 1 year from date of installation or a maximum of 2 years from shipment should be corrected by repair or replacement by the manufacturer fee on board (f.o.b.) factory."

9. __CONFIGURATION CONTROL PLAN__ Due to the modular nature of the AWOS, many system components such as sensors and peripheral devices may be interchangeable. Since type approval is given only to specific combinations of components, the manufacturer should establish a configuration control mechanism which should uniquely identify each FAA-approved system and the components which comprise them.. Before type approval is granted, the manufacturer should submit a configuration control plan. The manufacturer's configuration control system should be explained and should include the procedures for configuration control of all hardware and software system documentation. The identifying information for each system should be permanently inscribed on a system nameplate. Changes to an approved configuration should be submitted for FAA approval to the AWOS program office at the address listed on the front of this AC. Minor product improvement changes may be incorporated by the manufacturer after notifying and obtaining approval from the FAA. Major changes, such as a sensor or a major software change, should be fully supported by documentation and appropriate test data. (Major changes normally require the assignment of a new configuration number.) Every change to an approved AWOS should be supported by revised (configuration controlled) documentation. The-plan should also address:

a. Explanation of the manufacturer's arrangement for assigning a configuration identification number/symbol/etc., and the means used to identify which system components are included in a particular system configuration.

b. Procedures for notifying system owners of changes in the approved configuration of their AWOS.

c. Procedures for identifying and maintaining a record of the configuration of each operational system that has been sold and installed by the manufacturer.

d. A definition of major and minor product improvement changes.

e. Procedures for the configuration control of documentation, to include procedures for issuing changes, numbering, and dating pages.

10. PLANNING THE AWOS INSTALLATION.

a. All airport owners, sponsors, or other parties contemplating purchase and installation of a non-Federal AWOS should coordinate with the FAA in the planning stages of the project before the equipment is ordered. The regional FAA non-Federal System Coordinator is the official FAA point of contact and is responsible for the overall project coordination with the sponsor and other elements in the FAA. Airport sponsors obtaining a grant under the Airport Improvement Program (AIP) should also coordinate, in concert with the non-Federal System Coordinator, with the FAA Airport District Office or Field Office that has jurisdiction over their specific geographical area. The FAA non-Federal System Coordinator should coordinate the proposal with the FAA regional Flight Standards division, Air Traffic division, Security Division (Real Estate branch), and the regional Frequency Management Officer.

b. The selection of a voice outlet frequency for the AWOS is a critical issue. Therefore, it is advisable to coordinate with the regional Frequency Management Officer in the early planning stages of the facility, since there are a limited number of frequencies available for this purpose. The following order of priority has been established by the FAA, and should be used to the extent possible in establishing AWOS ground to air communications outlets:

(1) Very High Frequency (VHF) omnidirectional radio range (VOR) or VHF omnidirectional radio range/tactical air navigation (VORTAC) (except doppler VOR) with voice capability. The VOR/VORTAC must be located within three nautical miles of the airport.

(2) Assigned ATIS frequency. At part-time towered locations, the AWOS operates independently from the ATIS during non-operational hours and utilizes the existing ATIS voice outlet.

(3) Nondirectional beacon (NDB) with voice capability. The NDB must be located within three nautical miles of the airport. At locations where frequency congestion in the VHF air-ground band is not expected to be a problem, the use of an NDB shall be considered as the fourth priority.

(4) Any 25 kilohertz (kHz) discrete VHF air-ground communications channel in the air traffic control band (118-136 MHz). Any request for a discrete VHF frequency assignment shall include a justification statement on why an NDB or VOR/VORTAC is not being used for the AWOS transmission. The regional Frequency Management Officer shall include this justification in the supplementary details field in the frequency assignment application form.

c. If the AWOS system proposed for installation does not meet the requirements of this AC or any other FAA approved standards, the FAA may not assign the system a broadcast frequency.

d. After an AWOS III has been certified and commissioned by the FAA, it becomes the official airport weather observation. Any existing manual weather observation program whose hours conflict with the AWOS III should be terminated. However, as specified in paragraph 3c, the AWOS owner may elect to maintain a manual observation capability to back up the AWOS in the event the system, or any critical parameter (wind speed/ direction, ceiling/sky condition, visibility, altimeter setting), fails. In addition, the AWOS owner may elect to augment the AWOS output with specified parameters (e.g., thunderstorms or precipitation) that are not within the capability of the AWOS. In these cases, the Supplementary Aviation Weather Reporting Station (SAWRS) agreement with the NWS should be amended accordingly.

11. FACILITY COMMISSIONING The AWOS facility should be formally commissioned by the FAA before it becomes part of the NAS. After receiving approval of a broadcast frequency, the owner may procure and install the AWOS facility. At least 120 days prior to the anticipated commissioning date, the owner should notify the FAA regional Flight Standards division so that routine revisions may be made to the instrument approach procedures. As the system approaches operational readiness, the owner should request a commissioning ground inspection, which should be conducted by regional Airway Facilities (AF) personnel. This inspection includes participation by the owner or owner's maintenance representative. The commissioning inspection consists of the tests and checks in subparagraphs a.-e., a review of the operations and maintenance documents on file at the facility; and recording of facility performance data which should be retained as commissioning documentation in the FRDF.

a. Siting and Installation. The AWOS is a permanent facility and is located, constructed, and installed in accordance with applicable code requirements. It should be installed by a technician who is fully qualified in electronic applications who has a knowledge of the operations, testing, and maintenance of the AWOS, and is either a maintenance technician employed at the manufacturer% factory or has been certified by the FAA. The procedures in the FAA-approved Installation and Checkout Manual should be performed (par 8c). A regional FAA Airway Facilities representative should verify that the AWOS equipment was installed in accordance with the siting criteria contained in the current version of Order 6560.20, Siting Criteria for Automated Weather Observing Systems (AWOS), and that the checkout procedures have been performed. Any exceptions to the siting order should be justified as being the best practical solution to meeting the intent of the siting criteria. Any discrepancies found during this inspection should be rectified before the facility can be commissioned.

b. performance Test. The AWOS owner or maintenance representative should operate the system and should measure all system performance parameters described in the maintenance manual. These parameters are recorded on a Comprehensive Facility Performance and Adjustment Data form and retained at the facility in the FRDF as commissioning documentation.

c. Flight Inspection All NAVAID facilities (e.g., VOR, NDB) used as a voice outlet to broadcast'weather information should be flight inspected to assure that operation of the NAVAID has not been derogated. If, during flight inspection, it is determined that performance of the NAVAID has been affected, the AWOS should not be activated until the malfunction has been corrected (e.g. , through modification or by employing a separate discrete frequency transmitter to broadcast the weather). An AWOS utilizing a discrete frequency transmitter is not required to undergo a flight inspection.

d. Notification of the AWOS Program Office Following successful completion of the commissioning inspection, the FAA regional non-Federal System Coordinator should notify the FAA program office of the commissioning date, broadcast frequency, voice access telephone number, system owner, and maintenance arrangements.

e. Relocation of an AWOS. In the event that an AWOS is removed from service in order to be relocated, a "Decommissioning" NOTAM should be issued, instead of a "Facility out-of-service NOTAM." After relocation, a facility commissioning inspection should be performed.

12. ONSITE DOCUMENTATION The following documentation should comprise the FRDF. It should contain all pertinent onsite documentation and is to be maintained and kept at the facility. It should be reviewed by the FAA at the commissioning inspection.

a. Type Approval. A copy of the FAA letter to the manufacturer granting type approval for the AWOS system design. The subsystems should be inspected to verify that the AWOS installed is exactly the configuration for which the type approval was given.

b. Frequency Allocation Approval The documentation from the Federal Communications Commission (FCC) assigning the approved operating frequencies (if appropriate).

c. Manufacturer's Documentation Copies of the AWOS operating instructions (par 8d), manufacturer's maintenance'manual (par 8b), and system description (par 8a). When changes are made to these documents initially placed in the FRDF, the manufacturer should forward revisions to the AWOS owner.

d. Operational Procedures Site-specific operational procedures which set forth mandatory site procedures for both routine and nonscheduled situations. These procedures may incorporate appropriate sections of the manufacturer's manuals and should be available for inspection at the time of the commissioning inspection. The following items should be covered:

(1) Physical security of the facility.

(2) Maintenance and operations by authorized persons, including who to notify if a weather parameter is discovered out of tolerance or other maintenance is necessary.

(3) Posting of licenses and signs.

(4) Notice to the FAA when any AWOS service has been suspended, or when a critical weather parameter is out of tolerance.

(5) Keeping of station logs and other technical reports.

(6) Names, addresses, and telephone numbers of persons to be notified in the event of system failure.

(7) Procedures for shutdown for periodic scheduled maintenance, including the office to be notified to generate a NOTAM for routine or nonscheduled shutdowns. Also, an explanation of the kinds of activities (such as construction or grading) in the vicinity of the AWOS facility that may require shutdown or reverification of the AWOS.

(8) Procedures for amending or revising the instructions.

(9) Procedures to be followed to freeze the AWOS data in the archive file in the data processor for a specified period before and after the time of an aircraft accident or incident, and the procedures to be followed to retrieve this data. These procedures should assign the responsibility for accomplishing those actions. They should be automatically accomplished in the event of an accident or an incident, or upon the request of a member of the FAA.

(10) Locations of AWOS components on the airport. This includes the result of the survey to establish the elevation of the barometric pressure sensors.

(11) A Memorandum of Understanding signed by the owner and the FAA regional Airway Facilities and Logistics division managers. This memorandum should state that the owner agrees to maintain, repair, and modify the AWOS in accordance with the requirements, standards, or criteria governing AWOS, particularly those contained in the operation instructions and maintenance manuals. The owner understands that noncompliance with the requirements of this AC may result in removal from service or decommissioning of the AWOS.

(12) A copy of any agreement with the NWS to maintain a SAWRS capability to augment or back up the AWOS.

e. Commissioning Documentation. The Comprehensive Facility Performance and Adjustment Data Form completed during commissioning.

13. **MAINTENANCE PROGRAM**. At the time of facility commissioning, the owner should show that a maintenance program has been established. The maintenance program should cover a minimum period of 5 years (as established in par 8b) and should consist of properly trained personnel, adequate test equipment, and resources to fulfill the manufacturer% recommended scheduled maintenance and calibration procedures defined in the manufacturer's maintenance manual. The maintenance program is the responsibility of the owner but may be performed by the owner, the manufacturer, or a qualified third party.

a- Maintenance Personnel The owner should show that the maintenance program adopted has qualified'personnel available to maintain the AWOS system. Order 6700.20A (Non-Federal Navigational Aids and Air Traffic Control Facilities), paragraph 55.e, contains the qualifications for maintenance technicians that maintain non-Federal facilities, to include FAA technicians working during their off-duty hours as a maintenance technician on non-Federal AWOS. In addition, they should have the special knowledge and skills needed to maintain the AWOS facility and should have completed the manufacturer's training program (par 8e). They should be proficient in maintenance procedures and the use of specialized test equipment.

b. Test Equipment The owner should have available at the facility at the time of commissioning all test equipment required by the approved maintenance plan for maintenance and calibration of the facility. Test equipment should be calibrated in accordance with the schedule submitted to (and approved by) the FAA during Type Acceptance. Test equipment calibration should be traceable to National Standards, and proof of calibration (e.g., a current calibration sticker) should accompany each piece of test equipment when it is being used. After commissioning, the test equipment should be available when required for scheduled system maintenance and calibration or for repairs after system failure.

c. Annual Performance/Configuration Revalidation.. The owner should show provisions for complying with the manufacturer's recommended procedure for annual system revalidation (par 8f and 14). This plan should include a list of the procedures to be followed during the revalidation and the source of the qualified person to conduct the inspection.

14. ONGOING SYSTEM VALIDATION. To verify that the system is being properly maintained and that the system retains an approved configuration, the following ongoing validation program should be conducted. Failure to meet the criteria of this program may result in decommissioning the AWOS facility (i.e., withdrawal of the broadcast frequency authorization).

a. Performance/Co-ion Revalidation. Each AWOS should be annually inspected by an FAA regional qualified technical representative in accordance with the manufacturer's approved Annual System Revalidation Plan (par 8f). This inspection should include the items in subparagraphs (1) through (4), and the results should be recorded on a Comprehensive Facility Performance and Adjustment Data form and retained on file in the FRDF at the facility.

(1) **Verify** that the maintenance program is being followed and properly documented.

(2) Perform **a** comprehensive check and calibration to verify that system performance is within the limits specified by the manufacturer's documentation and to ensure that every component of the system is operating properly.

(3) Verify that the AWOS configuration is the same **as** approved at the time of commissioning or as formally modified in accordance with approved configuration control procedures. Additionally, it should be determined that all **mandatory** configuration changes approved by the FAA have been accomplished and documented.

(4) A summary of all maintenance (hardware and software) performed since the last report is on file at the facility.

b. FAA Site Visits. The FAA will visit certified non-Federal AWOS facilities. Through a review of the documentation at the AWOS site, the FAA representative will verify that the system operates within tolerance, that all maintenance tasks have been properly performed and documented, and that the AWOS configuration has been approved by the FAA. Scheduled (periodic) and unscheduled maintenance, and the documentation of these activities, should have been accomplished in accordance with the approved manufacturer's maintenance manual and the annual system revalidation plan provided to and approved by the FAA during the type approval process. The owner will provide the FAA representative with **access** to the sites in order to perform this inspection.

c. Mandatory Configuration Changes. If the FAA determines that an AWOS system, or any element of the system, is providing data which could be in error, the FAA may direct the system manufacturer to issue a mandatory configuration change order to the owners of similar systems. The system owner should disable the appropriate part of the system and should request that the FAA issue a **NOTAM** describing the missing parameter and giving an estimate of the time for which it **will** be disabled.

CHAPTER 3. PERFORMANCE AND TESTING SPECIFICATIONS FOR AWOS

15. GENERAL. This chapter contains the performance standards and testing specifications for components of the AWOS. Equipment should comply with the these standards in order to constitute a source of weather information to be used to satisfy the Federal Acquisition Regulations (FAR's). However, the following tests are intended to be performed in a laboratory environment and are not intended to be duplicated in the field. Field measurements (i.e., standards and tolerances during certification and annual verification) are detailed in the FAA-approved maintenance manual for each type certified AWOS.

16. DEFINITIONS.

a. Root Mean Square Error (RMSE). RMSE is determined by comparing the output value with the true value of a parameter according to the following equation:

$$\text{RMSE} = \left[\frac{1}{N} \sum_{N=1}^{N} (T-M)^2\right]^{1/2}$$

Where

N = Number of independent comparisons
M = Measured value
T = True value

b. Time Constant After a step change in the value of a parameter measured by a sensor, the time-constant is the length of time it takes the sensor to register a given percentage (63 percent unless otherwise specified) of the change.

c. Resolution. The resolution of a sensor is the value of the least significant digit which is given as sensor output.

d. Variance For the purposes of this AC, variance is defined as the difference between the value of the reference sensor and the sensor under test.

e. Thunderstorm. For purposes of this AC, a "thunderstorm" is a storm produced by a single cumulonimbus cloud (Le., a cell) and includes one or more forms of lightning. At any one time, a period of storm activity may consist of a number of thunderstorms (i.e., cells) within the area surrounding the reference point.

17. GENERAL PERFORMANCE STANDARDS This paragraph addresses aspects of performance which are applicable to the AWOS as a whole. The electromagnetic interference, transient, and lightning protection standards are also applicable to the entire system and are addressed in paragraphs 33 and 34.

a. Input Power. AWOS equipment operates from a 120/240 V (±10 percent), 60 Hz ac (±5 Hz), 3-wire single phase service.

b. Loss of Power. The AWOS system should return to normal operation without human intervention after a power outage. When power is restored, the system should not output erroneous data.

c. Wind Sensor Tower If a separate tower is used for the wind sensor, daytime marking and nighttime lighting should be provided in accordance with the guidelines set forth in AC 70/7460-1H, Specification for Obstruction Marking and Lighting.

(1) It should be lighted with a dual L-810 fixture placed within 5 feet of the top of the tower. The two lamps on the L-810 should be wired in parallel. The standards for the L-810 fixtures may be found in AC 150/5345-43, Specification for Obstruction Lighting Equipment, which may be ordered from the Department of Transportation, Utilization and Storage, M-443.2 Washington, D.C. 20590.

(2) Since the nominal height for this tower is 30 to 33 feet and since most towers are manufactured in 10 foot sections, a waiver to AC 70/7460-1H has been granted to permit a six-band marking, with the bands alternating between aviation orange (the top band) and aviation white. This pattern will permit dip painting the tower at the factory without sacrificing the level of safety provided by the standard tower.

d. VHF Transmitter It is FAA policy that the output of the AWOS will be transmitted on an existing navigational aid voice outlet whenever practical. When the AWOS is broadcast over a NAVAID, that NAVAID will be given a flight check during the initial commissioning procedure and will be given an annual flight check in conjunction with the annual AWOS verification. If there is no NAVAID available, then the output will be broadcast via a separate VHF transmitter which will be licensed by the FCC. The transmitter operates in the 118-137 MHz band on a frequency assigned by the FAA. The transmitter will have an FCC type-acceptance with the following operational parameters:

Channel Spacing:	25 kHz
RF Power Output:	nominal 5 watts, at the transmitter 10 watts maximum (under unusual circumstances, only with FAA approval)

NOTE: No compensation should be made to allow for antenna feed line losses.

Frequency Stability: ±0.001 percent (-30° to +60° C)

Emission Type: 6A3E

Spurious and harmonic emissions: 80 db down from the carrier minimum up to 90 percent modulation

Occupied Bandwidth No less than 99 percent of the emitted signal energy should be contained within a 25kHz bandwidth.

Deviation/percent modulation, Voltage Standing Wave Ratio (VSWR) at the transmitter and at the antenna, transmission line loss, and initial/operating power output should be in accordance with FCC regulations and good commercial practice and should be clearly defined in the manufacturer's maintenance manual. These parameters should be verified during the annual verification.

e. Generation of the NAVAID Identifier by the AWOS When the AWOS message is broadcast over a NAVAID, the AWOS should be designed-to provide both the NAVAID tone identifier and the AWOS weather data over the NAVAID frequency. The tone should be generated between every AWOS voiced weather message and should only be generated between messages. This design should eliminate the interference between the AWOS voice and the NAVAID generated tone identifier and provides for better identification of the NAVAID in marginal conditions. If this design is adopted, it is imperative that the NAVAID automatically return to using its internal tone generator to provide the identifier if the AWOS capability to provide the NAVAID identifier has been lost.

f. Very High Frequency (VHF)/ Ultra High Frequency (UHF) Data Link Radio Transmitter. When a VHF or UHF radio is used to transfer data between components of the system, the transmitter will have FCC type-acceptance, and the power output should be limited to the minimum necessary to accomplish the job and should not exceed one watt. The FCC will license the use of the facility and will assign the frequency. Frequency stability, deviation/percent modulation, Voltage Standing Wave Ratio (VSWR), and initial/operating power output should be in accordance with FCC regulations and should be clearly defined in the manufacturer's maintenance manual.

g. Code Requirements The AWOS should be designed in accordance with applicable paragraphs of the National Electrical Code (NEC) and should be installed in accordance with local code requirements.

18. OPERATING ENVIRONMENT AWOS equipment should operate under the environmental conditions described in this AC. Equipment that cannot satisfy the full range of conditions may be waivered for operation in locales where those conditions do not occur.

a. Site Elevation. From 100 feet below sea level to 10,000 feet above sea level.

b. Equipment Installed Indoors in a Conditioned Space.

(1) Temperature. From +40° to +105° F (+5° to +40° C).

(2) Relative Humidity. 5 percent to 90 percent (noncondensing).

c. Equipment Installed Outdoors.

(1) Temperature.

Class 1: -30° to +130° F (-35° to +55° C)
Class 2: -65° to +130° F (-55° to +55° C)

(2) Relative Humidity. 5 percent to 100 percent.

(3) Wind. Up to 85 knots.

(4) Hail. Up to 1/2 inch in diameter.

(5) Ice Build-up Freezing rain rate equivalent to a buildup of 1/2 inch per hour, lasting for a period of one hour. The accuracy of the wind sensors is permitted to deteriorate during icing conditions.

(6) Rain. Up to 3 inches per hour with 40 knot wind.

19. WIND SPEED AND DIRECTION SENSOR.

a. Performance Standard.

(1) Wind Speed Sensor.

(i) Range. The sensor should respond to a threshold of 2 knots and a maximum of at least 85 knots.

(ii) Accuracy. The wind speed sensor should provide an accuracy of 2 knots or 10 percent RMSE, whichever is greater, with a maximum error of 15 percent at any speed.

(iii) Resolution. The resolution should be one knot.

(iv) Distance Constant. The distance constant should be less than 10 meters. The method for calculation is given in subparagraph b(1) (ii).

(v) Threshold. Two knots.

(2) Wind Direction Sensor. This sensor should be aligned to true north and should withstand a wind speed of 85 knots without damage.

(i) Range. 1° to 360° in azimuth.

(ii) Threshold. 2 knots.

(iii) Accuracy. Within 5° (RMSE), with a maximum error of 10° on any direction.

(iv) Resolution. To nearest 1°; dead band not to exceed 10°.

(V) Time constant. Less than 2 seconds.

b. Performance Testing. Testing should be conducted in a calibrated wind tunnel, except for the wind direction accuracy test which is conducted on a bench test fixture. The wind-speed sensor should be compared against a calibrated pitot-static tube or transfer reference standard traceable to the National Bureau of Standards. The test procedure in subparagraphs (1) and (2) should be used:

(1) Wind Speed.

(i) Accuracy and Resolution. The test is conducted under "no rain" conditions. Four full test cycles (2 - 85 knots) should be conducted in increments of 2 knots between 2 and 10 knots, in increments of 10 knots between 10 and 80 knots, and at 85 knots. During these test runs, data should be gathered to demonstrate compliance with the requirements for accuracy and resolution.

(ii) Distance Constant. The distance constant should be computed according to the following formula:

$$D = T \times W$$

Where:

D = Distant Constant (in meters).
T = Time constant.
W = Wind speed (meters per second) in the wind tunnel.

The distance constant should be determined from an average of 10 runs (5 runs each with the tunnel wind speed at 10 knots [5 meter/sec.] and at 20 knots [10 meter/sec] with the sensor propeller speed at the zero at time zero). The distance constant should be less than 10 meters for the sensor to pass this test. If the sensor is of a type with no moving parts (i.e., no propeller), the manufacturer should develop a test for FAA approval to demonstrate compliance with the distance constant requirement.

(2) Wind Direction.

(i) Accuracy. This test should be conducted on a bench test fixture under "no rain" conditions. The accuracy of the sensor should be checked at each 15° increment. The accuracy should be checked in 2° increments between 350° and 010° (a dead band of up to 10° is permissible). Two complete test cycles should be conducted, and RMSE accuracy should be within specified limits.

(ii) Time Constant The time constant should be determined from an average of 10 runs (5 runs each with the tunnel speed at 10 knots and at 20 knots). The vane should be displaced 10° from the indicated wind direction and released. The time constant should be less than 2 seconds to reach within 5° of the indicated wind direction.

20. AMBIENT TEMPERATURE SENSOR.

a. Performance Standards. The sensor should be thermally isolated to accurately measure the environments below.

(1) Range. From -35° to +55°C (-30° to +130°F) for Class 1 systems.

From -55° to +55°C (-65° to +130°F) for Class 2 systems.

(2) Accuracy. 1°F RMSE for the entire range of the sensor, with a maximum error of 2°F.

(3) Resolution. Not greater than 1°F.

(4) Time Constant. Not greater than 2 minutes.

b. Performance Testing.

(1) Accuracy. Temperature accuracy should be verified using a calibrated reference instrument traceable to the National Bureau of Standards. The temperature sensor should be exercised through the full range of the device in 20°F increments. This 20° change in chamber temperature should be accomplished within 5 minutes, and the sensor reading should be taken 5 minutes after the chamber temperature is stable. This test cycle should be performed a total of eight times (or four times with two sensors in the chamber). These cycles should include two increasing and two decreasing temperature cycles without radiation heating; and two increasing and two decreasing temperature

cycles, with radiation heating on the aspirated enclosure of 1.6 gram-calories per square centimeter per minute. The accuracy of the sensor should be within 1°F (RMSE) for each test cycle (a total of 9 data points for each Class 1 system cycle; 11 data points for each Class II system cycle).

(2) Time Constant The sensor should be placed in a chamber and stabilized at 85°F. The temperature should be rapidly raised (within one minute) 5° (to 90°F); the time constant should be 2 minutes or less. The same test should be repeated with a 5° decrease in temperature within one minute. The time constant should be 2 minutes or less.

21. DEWPOINT SENSOR. A single thermal shield and aspirator unit may include both the dewpoint and temperature sensors.

a. Performance-

(1) Operating Range. From -30° to +90°F

(2) Dewcell Protection If the dewpoint sensor is a dewcell, it should not be damaged if the sensor becomes excessively wet (e.g., from precipitation or from absorption of moisture after a loss of power). The dewcell probe should return to normal operation, without damage and without human intervention, within 30 minutes after the abnormal, excessively wet condition is alleviated (i.e., after precipitation ends) or after restoration of power.

(3) Resolution. Not greater than 1°F.

(4) Time constant. Less than 2 minutes.

(5) Accuracy. The accuracy should be as follows (all errors are RMSE):

(i) 2°F dewpoint for dry bulb temperatures of +30° to +90°F (80 to 100 percent relative humidity), with a maximum error of 3°F at any dry bulb temperature.

(ii) 3°F dewpoint for dry bulb temperature of +30° to +120°F (15 to 75 percent relative humidity) with a maximum error of 4°F at any dry bulb temperature.

(iv) 4°F dewpoint for dry bulb temperatures of -20° to +20°F (25 to 95 percent relative humidity) with a maximum error of 5° at any dry bulb temperature. The minimum dewpoint required is -30°F.

b. Performance Testing.

(1) Accuracy. All tests should be performed with the sensor in the aspirated enclosure supplied with the sensor. Temperature and dewpoint accuracy should be verified using calibrated reference instruments traceable to the National Bureau of Standards. The data points given in subparagraphs (i) through (iii) should be taken during four test runs (two with increasing humidity and two with decreasing humidity.) This may be reduced to two test runs if two sensors are placed in the chamber. During the test run, the change in temperature and/or relative humidity should be accomplished within 5 minutes, and the sensor reading should be taken 5 minutes after the temperature and humidity have stabilized. The following data points should be demonstrated and the RMSE calculated to demonstrate the error in each category.

(i) With an error not to exceed 2°F (RMSE) dewpoint,
30°F temperature; 80, 90, 100 percent relative humidity
60°F temperature; 80, 90, 100 percent relative humidity
90°F temperature; 80, 90, 100 percent relative humidity

(ii) With an error not to exceed 3°F (RMSE) dewpoint,
30°F temperature; 15, 45, 75 percent relative humidity
60°F temperature; 15, 45, 75 percent relative humidity
90°F temperature; 15, 45, 75 percent relative humidity
120°F temperature; 15, 40 percent relative humidity

(iii) With an error not to exceed 4°F (RMSE) dewpoint,
-20°F temperature; between 65 and 95 percent relative humidity
0°F temperature; 25, 60, 95 percent relative humidity
+20°F temperature; 25, 60, 95 percent relative humidity

(2) Time Constant. At ambient temperature and 50 percent relative humidity, change the dewpoint +5°F (within one minute) , and then -5°F (within 1 minute). In each case, the time constant should be less than 2 minutes.

(3) Power Interruption At ambient temperature and 90 percent relative humidity with the sensor operating normally, disconnect the power from the sensor for a period of 1 hour. Power should then be reapplied, and the sensor should return to normal operation and accuracy within 30 minutes.

22. PRESSURE SENSOR.

a. Design. Two pressure sensors should be provided for each AWOS system. The pressure sensors should have provisions for venting to the outside of the building where required. Pressure variations due to airflow over the venting interface should be avoided. The venting interface should be designed to avoid and damp pressure variation and oscillation due to "pumping" or "breathing" of the pressure sensor, venting, and porting equipment. Each sensor should have an independent venting interface (from separate outside vents through dedicated piping to the sensors). Means should be provided to avoid insect nesting and moisture entrapment in the venting interface.

b . Performance S t -

(1) Altitude Ranges. High pressure should be standard atmospheric pressure at -100 feet plus 1.5 inHg (30.65 + 1.5 = 31.565 inHg). Low pressure should be standard atmospheric pressure at +10,000 feet minus 3.0 inHg (20.58 - 3.00 = 17.58 inHg).

(2) Pressure Range. The sensor should be capable of measuring a pressure range at any fixed location (station) of +1.5 to -3.0 inHg from the standard atmospheric pressure at that location. Pressure sensors should have a provision for setting the sensor to the station elevation to the nearest 1 foot over the range of -100 feet to +10,000 feet.

(3) Accuracy. The accuracy should be 0.01 inHg RMSE at all altitudes from -100 to +10,000 feet mean sea level (MSL), maximum error 0.02 inHg at any one pressure

(4) Resolution. The resolution should not be greater than 0.005 inHg.

(5) Differential Accuracy. The sensor should exhibit an average differential accuracy of 0.01 inHg or less between a series of two pressure measurements taken from the same sensor 3 hours apart. Ambient temperature over this 3-hour period should not change more than 5°F; ambient pressure should not vary more than 0.1 inHg (RMSE) over the 3-hour period.

(6) Maximum Drift With Time. Each sensor should be stable and continuously accurate within 0.01 inHg RMSE for a period of not less than 6 months. The maximum error should be 0.02 inHg.

c. Performance Tests.

(1) Accuracy. Both pressure sensors should successfully complete the following accuracy test. A calibrated barometer or transfer standard with an accuracy of at least 0.003 inHg that is traceable to the National Bureau of Standards should be used as a standard during testing. Two test cycles should be performed on each pressure sensor. One test cycle is defined as running the sensor through the full pressure range at each of the three ambient temperatures. Before taking measurements, allow sufficient time for the sensor to achieve steady state at each data point (not to exceed 5 minutes). The RMSE should be within the specified limits.

(i) Pressure Range. The pressure sensors should be tested through the full range of performance (normally 17.5 to 32.0 inHg) in 1 inHg increments of both increasing and decreasing pressure. Partial range (4.5 inHg) pressure sensors should be tested by setting the sensor to a pressure altitude from zero to 10,000 feet in 500 foot increments. The sensor should be tested from minus 3.0 inHg to +1.5 inHg at 0.5 inHg increments at each pressure altitude.

(ii) Temperature Range. The sensor should be tested at ambient (approximately +85°F), and at the hot and cold extremes called for in the environmental requirements.

(2) Differential Accuracy. Differential accuracy (change in accuracy) of the pressure sensor should be tested at ambient temperature (approximately 85°F) and ambient barometric pressure.

(i) Take 14 measurements of pressure on the pressure sensor under test and 14 measurements of pressure on the reference barometer. These measurements should be taken about 5 seconds apart, and all 14 measurements should be completed within 90 seconds. This time should be called t=0.

(ii) Repeat the 14 measurements on the pressure sensor under test and 14 measurements of pressure on the reference barometer after an elapsed time of 3 hours. The ambient temperature should have changed less than 5°F, and the ambient pressure should have changed not more than 0.1 inHg. This time should be called t=3.

(iii) Compute the average reading of the reference barometer at t=0. Compute the average reading of the reference barometer at t=3. Determine the difference in the two averages. If the difference is greater than 0.1 inHg, or if the average difference between the reference and the test barometer at either t=O or t=3 is greater than 0.02 inHg, repeat steps (i) and (ii).

(iv) Compute the 14 errors in reading between the sensor and reference barometer at t=O.

(v) Compute the 14 errors in reading between the sensor and reference barometer at t=3.

(vi) Subtract the 14 t=O errors from the 14 t=3 errors determined in steps (iv) and (v). Preserve the order of subtraction such that the first t=O error is subtracted from the first t-3 error. These differences are the changes in accuracy (the differential accuracy).

(vii) Compute the average and standard deviation of the 14 changes in accuracy determined in step (vi). The average differential accuracy should be no greater than 0.010 inHg. The standard deviation should be less than 0.003 inHg.

(3) Resolution. The manufacturer should demonstrate that the resolution is not greater than ±0.005 inHg.

(4) Drift Over Time Testing should be done to determine maximum drift [paragraph 22b(6)] over a 6-month period.

23. CLOUD HEIGHT SENSOR.

a. General. The cloud height sensor should have a design range of 12,500 feet, or greater. The sensor should provide an output of three cloud layers representative of the sky conditions when surface visibilities are equal to or greater than 1/4 mile. Sensors should comply with the performance standards throughout their design range.

b. Performance Standards. The sensor should detect the height of atmospheric phenomena (i.e., clouds and obscuring phenomena aloft) or, in the event the phenomena are surface based (e.g., fog), provide an estimate of the contact height (CH) or vertical visibility (W). CH is defined as the vertical height above ground at which visual reference to recognized lights or objects on the surface can be established sufficiently to permit visual determination of the ground plane and position. W is defined as the vertical distance that an observer can see vertically into surface-based obscuring phenomena (e.g., dust, fog, sand, etc.), or the height corresponding to the upper limit of the return of the ceilometer signal, or the height corresponding to the height at which a balloon would completely disappear during the presence of surface-based phenomena (i.e., an obscured sky). The sensor should have the capability of discriminating between a negative response (i.e., no hit), resulting from no phenomena within the sensor's design range, and a sensor error/fault. The sensor should not indicate a response (i.e., hit) that is not the result of the detection of atmospheric phenomena.

(1) Range. The sensor should measure cloud heights and the heights of obscuring phenomena aloft to a minimum of 12,500 feet.

(2) Accuracy. Under laboratory conditions, the sensor should provide an accuracy of 100 feet or 5 percent, whichever is greater.

(3) Resolution. Not greater than: 50 feet surface to 5,500 feet; 250 feet from 5,501 to 10,000 feet; 500 feet above 10,000 feet.

(4) Detection Performance. The sensor should perform within the limits specified in paragraphs 23c(2) and 23c(3).

(5) Sampling. The sensor should provide an output at least once every 30 seconds. However, to extend sensor life, this sampling rate may be reduced to provide at least one sample every 3 minutes when no cloud, obscuring phenomena aloft, or CH/VV values (i.e., hits) are detected for the preceding 15 minutes.

(6) Eye Safety. The cloud height sensor should be designed to conform to ANSI-Z 136.1, Accessible Emission Limits for Laser Radiation, with Class 3b

maximum accessible emission level applied to direct viewing without optical instruments (excluding ordinary eye glasses). This document may be obtained from the American National Standards Institute, 1430 Broadway, New York, New York, 10018. Interlock device(s) in the laser power circuit should be provided to disable the laser when any doors are open or the cover is removed to prevent inadvertent exposure of the laser emission to the eyes of the technician or others. The interlock(s) may have a manual override in order that power can be purposely restored during maintenance.

(7) Laser Power Stability. The sensor should contain a self-check, self adjusting feature that should maintain laser output power at the level necessary to sustain sensor detection and accuracy. When this adjustment can no longer provide the compensation necessary to maintain the sensor within specified operational limits, sensor operation should be terminated.

(8) Optics Contamination An air blower or other device should be used to reduce the contamination of the sensor optics. A signal should be generated to indicate the amount of optics contamination, thereby indicating the need for optics cleaning.

(i) Snow. The ceilometer window should demonstrate an ability to remain clear of snow under the condition of snow accumulating at a rate of 2 inches per hour for 1 hour at a temperature of 20°F.

(ii) Ice. The ceilometer window should remain clear of ice for 60 minutes under conditions of freezing rain with a maximum accretion rate of 1/2 inch per hour radial thickness of clear ice.

c. Performance Testing.

(1) Accuracy Test. The signal should be projected horizontally to a target at known distances (two distances, separated by at least 1,000 feet, from 100 to 5,500 feet; two distances, separated by at least 1,000 feet, from 5,600 to 10,000 feet; and one distance beyond 10,000 feet). All range points should be within the accuracies specified in paragraph 23b(2). This test is a laboratory test conducted at full rated power output. It is not intended to be duplicated when the AWOS is installed in the field.

(2) Detection Tests Under Uniform Skv Conditions.

(i) Test Conditions. The sensor should be tested under the following conditions:

Group A. Visibility greater than 3 miles, with a minimum of 10 percent of the data sets in each subgroup (table 1) collected with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Table 1. Group A Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Group B. Visibility equal to or less than 3 miles, but equal to or greater than 1 mile, with a minimum of 10 percent of the data sets in each subgroup (table 2) with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Group C. Visibility equal to or greater than 1/4, but less than 1 mile, with a minimum of 10 percent of the data sets in each subgroup (table 3) collected with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Table 2. Group B Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Table 3. Group C Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Group D. Not more than 3/10 total sky coverage with the lowest cloud layer at 20,000 feet or higher under the visibility conditions in table 4, with a maximum of 80 percent of the data in each subgroup collected under daytime conditions.

Table 4. Group D Test Conditions

Subgroup	Visibility (miles)
1	Equal to or greater than 1, but less than 3
2	Equal to or greater than 3, but less than 7
3	Equal to or greater than 7

(ii) Collection of Test Data.

A. A minimum of 25 data sets should be collected for each subgroup in Groups A through C (i.e., a minimum of 125 data sets should be collected under each group). However, if weather conditions at the test site over a period of 1 year make collection of at least 25 data sets in every subgroup impossible, the FAA should consider approval of a lesser number of data sets in the affected subgroups, after analysis of available data. Further, for test data to be acceptable, a continuous test period should be selected to allow for collection of representative data.

Also, it should be clear that all data collected during the test period were considered. Any data not used should be explained. For example, if data analysis in a subgroup is truncated after 25 data sets are analyzed, this fact should be documented and explained.

One data set is defined as the second N-minute period during which a uniform cloud or obscuration is detected by a rotating beam ceilometer (RBC) or is determined by a qualified weather observer. In order to be classified as a uniform cloud or obscuration, the RBC should continuously measure (or a qualified weather observer should determine) a cloud, obscuration aloft, or vertical visibility height (for a 30-minute period) that does not vary from its mean height more than the variance shown in table 5·more than 5 percent of the time.

B. A minimum of 25 data sets should be collected for each subgroup under Group D. One data set is defined as the second lo-minute period of any consecutive 30-minute period during which the cloud/sky coverage/visibility conditions specified for group D are met.

Table 5. Criteria for Determining Uniform Cloud Layers

Mean Height (as determined by observer or as measured by RBC)	Variance (feet)
Equal to or less than 1,000 ft.	200
Greater than 1,000 ft., but equal to or less than 2,000 ft.	300
Greater than 2,000 ft., but equal to or less than 3,000 ft.	400
Greater than 3,000 ft., but equal to or less than 5,000 ft.	500
Greater than 5,000 ft., but equal to or less than 7,000 ft.	600
Greater than 7,000 ft., but equal to or less than 9,000 ft.	700
Greater than 9,000 ft., but equal to or less than 12,500 ft.	800

(iii) Test Standards

A. An FAA-approved cloud height indicator whose accuracy is traceable to a NWS approved and calibrated RBC, or observations taken by a qualified weather observer, should be the standard for determining heights and sky conditions.

B. An FAA-approved visibility sensor whose accuracy is traceable to an FAA standard should be the standard for determining visibilities.

C. Liquid precipitation measurements should be made using an FAA-approved 0.01 inch per tip tipping bucket precipitation gage. Light precipitation is defined as one, but not more than two buckets tips in a 10-minute period. Moderate precipitation is defined as more than two, but not more than five tips in a lo-minute period. Heavy precipitation is defined as more than five tips in a lo-minute period. The intensity of frozen precipitation should be determined by a qualified weather observer.

(iv) Criteria for Acceptance Under Uniform Skv Conditions.

A. Groups A. B, and C conditions The mean height of the cloud, obscuration aloft, or vertical visibility (measured by the RBC or determined by a qualified weather observer) should be determined for each data set. The variance for each cloud, obscuration aloft, and cloud height/vertical visibility (CH/VV) height (i.e., hit) detected by the candidate sensor in each data set should be computed. Eighty-eight percent of the data sets within a subgroup (e.g., 22 out of 25 minimum) should satisfy the following condition: 90 percent of the heights determined by the candidate sensor in each data set should agree with the mean height measured by the RBC or determined by a qualified weather observer within the variance limits as shown in table 6. Negative responses, i.e., no hits by the candidate sensor, should be included as data points and considered to be outside the variance limits. Also, the no-hit percentage in each subgroup should not exceed 5 percent. The candidate sensor should successfully demonstrate the conditions in table 6 for each subgroup to pass this test. Failure of any subgroup constitutes failure of the test.

B. Group D conditions. Not more than one false hit per data set in each subgroup. More than one false hit per data set should constitute failure of the test.

(3) Detection Tests Under Ragged Overcast or Obscured Sky Conditions.

(a) Heights (cloud/obscuration aloft or CH/VV) measured by the candidate sensor should be compared with heights measured by the RBC or determined by a qualified weather observer during ragged overcast or obscured sky conditions. Valid data should be that collected during overcast or obscured sky conditions below 12,500 feet as verified by an RBC hit percentage of 95 percent or more, or as determined by a qualified weather observer, during a 20-minute period. Negative responses, i.e., no hits, should be included as data points and considered to be outside the variance limits. Calculate the percent of heights (i.e., hits) by the candidate sensor falling within the ranges in subparagraph (i) under each of the conditions specified in subparagraph (ii) with allowable height variances as specified as in Table 6. Data should be collected under as many of the conditions as possible; however the FAA may accept less than the specified requirement after evaluation of the available data. For test data to be accepted, a continuous test period should be selected to allow for representative data collection. It should also be clear that all data collected during the test period were considered. Any data not used should be explained.

Table 6. Criteria To Satisfy Groups A, B, and C Conditions

Mean Height (as determined by observer, or as measured by RBC)	Variance (feet), for cloud and obscuration aloft heights (feet)	Variance for CH/VV values (feet)
Equal to or less than 1,000 ft.	200	400
Greater than 1,000 ft., but equal to or less than 2,000 ft.	300	600
Greater than 2,000 ft., but equal to or less than 3,000 ft.	400	800
Greater than 3,000 ft., but equal to or less than 5,000 ft.	500	1000
Greater than 5,000 ft., but equal to or less than 7,000 ft.	600	1200
Greater than 7,000 ft., but equal to or less than 9,000 ft.	700	1400
Greater than 9,000 ft., but equal to or less than 12,500 ft.	800	1600

(i) Height ranges (as determined by RBC or qualified observer)

A. 100 - 700 feet

B. 800 - 1,500 feet

C. 1,600 - 3,000 feet

D. 3,100 - 5,500 feet

E. 5,600 - 12,500 feet

(ii) Conditions:

A. No precipitation. Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

B. Light or moderate precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

C. Heavy precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(iii) A minimum of 90 percent weighted average of the hits by the candidate sensor should fall within the range of the RBC or within the height range determined by a qualified weather observer. Also, the weighted negative response, (i.e., no hit) percentage should not exceed 5 percent.

24. VISIBILITY SENSOR.

a. Performance Standards.

(1) Range. The visibility sensor should be capable of determining visibilities from less than 1/4 mile to 10 miles. A method of calibration traceable to the FAA approved standards in paragraph 24b should be provided.

(2) Resolution. In terms of equivalent visibility, the sensor should provide data to report visibility values as follows (in statute miles): less than 1/4, 1/4, 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 5, 7, and 10 miles. For information, revisions to the Federal Standard Algorithms and the ADAS Interface Control Document (ICD) are being processed to add the following additional incremental reporting values (in statute miles) for AWOS located with an Airport Traffic Control Tower: 3/8, 5/8, 7/8, 2-1/4, and 2-3/4 miles.

(3) Accuracy. The sensor should agree with the transmissometer standards as follows:

Table 7. Visibility Sensor Accuracy Requirement

Reference Transmissometer Reading	Acceptable Sensor Variance
1/4 through 1-1/4	± 1/4
1-1/2 through 1-3/4	+ 1/4, -1/2
2 through 2-1/2	± 1/2
3 through 3-1/2	+ 1/2, -1
4, and greater than 4	± 1

(4) Time Constant. The time constant should not exceed 3 minutes.

(5) Ambient Light Sensor. The visibility sensor should contain an ambient light sensor (i.e., a photocell) to measure the ambient luminance within its field of view and to generate a signal to the visibility sensor to indicate whether the ambient light level is day or night. It should indicate day for increasing illumination between 0.5 and 3 footcandles (FC) and night for decreasing illumination between 3 and 0.5 FC. This sensor may be exposed to ambient light levels as high as 50 FC.

b. FAA Approved Visibility Standards. The high visibility reference standard should be a visible light transmissometer(s) that uses a narrow band of light centered at 0.55 microns (95 percent of the response within ±0.03 microns of 0.55 microns) for visibility ranges to an extinction coefficient of 3 $mile^{-1}$. At higher extinction coefficients, an FAA-approved transmissometer(s) that includes some infrared radiation may be substituted as a standard. Comparisons with scatter-type instruments (different from those being tested) may be used to correct for small drifts in reference standard calibration.

c. Performance Tests. The visibility sensor should be tested using FAA-approved transmissometers as the reference standard.

(1) Accuracy Testing.

(i), At least 2 months of accuracy test data should be accumulated, assuring that a representative number of valid test points are experienced at each of the reporting increments [par 24a(2)] and under conditions of both with and without precipitation. All data collected during the test should be included in the test report. Any samples not included in determining the candidate sensor's accuracy should be fully explained. For example, data collected under inhomogeneous conditions may be excluded from the accuracy analysis, if so explained. The test data should consist of a number of independent samples of 10 minutes each, with at least 5 minutes between each sample. Samples should consist of visibilities from less than 1/4 mile to greater than 10 miles and should be weighted in the following ratio:

70 percent without precipitation (i.e, with fog; under clear conditions; and with approximately 5 percent of the data points collected under summer haze conditions)

30 percent with precipitation (e.g., 15 percent with rain, 15 percent with snow)

(ii) Eighty percent (overall weighted average) of the total of all sensor test data points should agree with the transmissometer standard within the allowed variances from less than 1/4 through 5 miles.

(iii) Eighty percent of the sensor test samples that are obtained when the transmissometer reads greater than 5 miles should be 5 miles or greater.

(2) Time Constant Demonstration Under conditions of 10-mile visibility, a technique should be used to reduce the sensor detector output to 1 mile or less. After the restriction is applied, the time constant should be measured to reflect the reduction of visibility. After a period of 10 minutes, the artificial restriction to visibility should be removed, and the sensor time constant should be measured to reflect the increase in visibility. The time constant should be equal to or less than 3 minutes.

(3) Ambient Light Sensor Testing The manufacturer should demonstrate that the ambient light sensor complies with paragraph 24a(5).

25. PRECIPITATION OCCURRENCE AND ACCUMULATION SENSOR(S). The term "precipitation" is defined as including all forms, i.e., liquid, freezing, frozen, or combinations thereof. The term "precipitation amount" is the liquid or liquid equivalent amount. The precipitation sensor provides an indication of precipitation occurrence and measures the precipitation amount. The sensor(s) may be designed as a single or separate unit.

a. Performance Standards.

(1) Precipitation Occurrence Sensor. The sensor should detect the occurrence of precipitation as specified. It should not "false alarm" on other moisture sources such as dew and frost.

(i) Precipitation Onset. The sensor should detect the onset of precipitation 95 percent of the time as follows:

A. With the precipitation rate of 0.11 inches per hour or more, the sensor should detect the onset of precipitation within 1 minute.

B. With precipitation rates of 0.05 to 0.10 inches per hour, the sensor should detect the onset of precipitation within 2 minutes.

C. With precipitation rates of 0.01 to 0.04 inches per hour, the sensor should detect the onset of precipitation within 5 minutes.

D. With a precipitation rate of less than 0.01, but equal to or greater than 0.0005 inches per hour, the goal should be the detection of the onset of precipitation within 10 minutes.

(ii) Precipitation Cessation. The sensor should detect the cessation of precipitation within 5 minutes 95 percent of the time.

(2) Precipitation (Liquid Equivalent) Accumulation The sensor should be capable of measuring the precipitation amount with a range of 0.01 to 5 inches per hour, with a resolution of 0.01 inches and an accuracy of 0.002 inches per hour (RMSE) or 4 percent of actual (which ever is greater).

b. Performance Testing The manufacturer should conduct a test program to demonstrate that the precipitation occurrence and accumulation sensor(s) meet the performance requirements under the environmental conditions found in paragraph 18.

26. Precipitation Type Sensor The term "precipitation type" as used herein includes the following: rain, drizzle, snow, ice pellets, and hail. The precipitation type sensor should provide an indication of the type of precipitation occurring, or should output "precipitation" for any precipitation (liquid, freezing, frozen, or combinations thereof) when a type cannot be identified. However, recognizing that the sensor technology is not yet available to identify ice pellets and hail, a precipitation type sensor may qualify by identifying only rain, drizzle and snow, while outputting "precipitation" for those types not identified. The sensor unit may be designed as a separate unit or may be combined with the requirements of other parts of this AC (e.g., paragraph 24) so that one unit fulfills the requirements of two or more paragraphs.

a. The sensor should identify the type of precipitation when the rate of precipitation equals or exceeds 0.002 inch per hour, with the goals for accuracy as follows:

(1) Within the temperature range of:

(i) +28°F to +38°F, identify precipitation type correctly as:

A. Rain: 90 percent of the cases.

B. Drizzle: 80 percent of the cases.

C. Snow: 90 percent of the cases.

D. Ice pellets (optional): 50 percent of the cases.

(ii) Less than +28°F. Identify precipitation type correctly as snow in 99 percent of the cases.

(iii) Greater than +38°F, identify precipitation type correctly as:

A. Rain: 99 percent of the cases.

B. Drizzle: 90 percent of the cases.

C. Hail (optional): 90 percent of the cases.

(2) Priority: Only one precipitation type should be reported, with a the reporting priority established in subparagraphs (a) through (f).

(a). Hail.

(b). Ice pellets.

(c). Snow.

(d). Rain.

(e). Drizzle.

(f). Precipitation, no type defined.

b. Performance Tests The manufacturer should conduct a test program to demonstrate that the sensor satisfies the performance standards, under the environmental conditions in paragraph **18**. As a minimum, the following test conditions should be satisfied.

(1) Prior to testing, the AWOS manufacturer should develop and submit a test plan to the FAA for approval to the address shown at the front of this **AC.** The test plan should clearly outline the tests to be performed; it should define the capabilities of the sensor to be tested and should include a detailed description of the test procedures. It should contain a clear statement of pass/fail criteria. The test plan should identify the location(s) and the proposed time planned for the tests. All data collected during the test should be incorporated into the test report. Any data not included in determining the candidate sensors compliance with the requirements of this circular should be fully explained.

(2) The test should be conducted in two phases. One phase should be conducted in a test chamber with varying conditions simulated to generate drizzle, rain, snow, hail, and ice pellets. At least 15 events (at various rates

of accumulation) should be'simulated for each of these conditions to demonstrate the above requirements, and the results should be included in the test report.

(3) The second phase of the test should be conducted at a location(s) and during the times when there is a propensity for drizzle, rain, snow, hail, and ice pellets, and where there is a qualified weather observer on duty. The test report should compare the performance of the sensor under test with the log maintained by the official observer at the test location.

27. Thunderstorm Detection Sensor or Network. This stand-alone sensor or thunderstorm detection network should detect the presence of a thunderstorm in the vicinity of an airport, should locate the thunderstorm, and should provide this data in such a form that the information can be incorporated into the AWOS voice and data weather message.

a. Performance Standards.

(1) Range and direction Thunderstorms within 30 nautical miles (nm) of the reference point on the airport should be reported. Direction is expressed in compass octants for distances from 10 to 30Nnm.

(2) Resolution. The thunderstorm location should be defined within one nm of the location of the actual location of the thunderstorm/lightning

(3) Accuracy.

(i) The standard detects strikes within 10 nm of the reference point:

A. Detection Accuracy. Ninety percent of all thunderstorms identified and located within this area by the thunderstorm sensor/network standards should have been detected by the thunderstorm sensor/network under test.

B. Location Accuracy. The distance from each thunderstorm located by the sensor standard within 10 nm of the reference point, and the corresponding thunderstorm located by the sensor/network under test, should be computed. The RMSE of these distances accumulated during the test period should not exceed 3 nm.

(ii) The standard detects strikes between 10 nm and 30 nm of the reference point:

A. Detection Accuracy. Eighty percent of all thunderstorms identified and located within this area by the thunderstorm sensor/network standards should have been detected by the thunderstorm sensor/network under test.

B. <u>Location Accuracy</u> The distance from each thunderstorm located by the sensor standard between.10 nm and **30** nm of the reference point, and the corresponding thunderstorm located by the sensor/network under test, should be computed. The RMSE of these distances accumulated during the test period should not exceed **6** nm.

(4) <u>False Reports</u>. Not more than 2 percent of all thunderstorms reported by the sensor under test should have been caused by sources other than a naturally occurring thunderstorm.

(5) <u>Sensor/System Reporting to the AWOS</u>.

(i) The thunderstorm sensor/network should provide an updated output to the AWOS at least every minute.

(ii) The thunderstorm sensor/network should update the AWOS once each minute.

B. <u>Performance Tests</u>. The manufacturer should conduct a test program to demonstrate that the thunderstorm sensor/network meets the performance standards under the environmental conditions identified in paragraph **18**.

(1) <u>Prior to Testing</u> The AWOS manufacturer should develop and submit a test plan to the FAA for approval at the address shown at the front of this AC. The test plan should outline the tests to be performed; it should clearly define the capabilities of the sensor/network to be tested and should include a detailed description of, and the capabilities of, the method that should be used to prove that the sensor is performing in accordance with the performance standards (par 27a). It should define the criteria necessary for the standard(s), as well as the sensor/network under test, to recognize a thunderstorm. A clear statement of pass/fail criteria should be included. If the sensor/network proposed should only detect cloud-to-ground lightning or if it should detect other evidence of a thunderstorm, this fact should be clearly identified. The test plan should identify the locations and the proposed time planned for the tests.

(2) <u>Duration of the Test</u>. The test should be conducted in at least two locations (i.e., reference points) where there is a propensity for thunderstorms. It should encompass a sufficient period of time to accomplish the following minimum detection/location events to prove that the sensor/network under test conforms with the requirements of this circular. A <u>thunderstorm dav</u> is a day during which thunderstorm data are accumulated from the standard(s) and the sensor/network under test.

(i) <u>Summer Environment</u>. Thunderstorms should have been detected during at least **25** <u>thunderstorm days</u> during the summer months at a location where there is a high level of thunderstorms generated by summertime convection activity. It is desirable that at least 100 thunderstorms (i.e., cells) should have **been** detected and located by the standard(s) during the summer test.

(ii) Winter Environment. Thunderstorms should have been detected during at least **10** thunderstorm days during the months of November through February at a cold weather location where there is a propensity for thunderstorms associated with mid-latitude winter storms. It is desirable that at least 20 thunderstorms (i.e., cells) should have been detected and located by the standard(s) during the winter test.

(3) Thunderstorm All means available within the test area to identify and locate thunderstorms should be used. These **"standards"** should include:

(i) Qualified Weather Observer(s). Qualified weather observers should be used to identify and locate thunderstorms within the vicinity of the **reference point**. The observer should identify a thunderstorm in accordance with the criteria in **FMH-1**. The time and the estimated location (bearing and **distance)** should be logged when identifying the existence (beginning time) of a thunderstorm. Once a thunderstorm has been identified, observations should be recorded every **10** minutes. The ending time of the thunderstorm should be identified. The results of these observations should be plotted on a grid of approximately 3 nm squares, with the reference point in the center, and an area encompassing a circle with a radius of **10** nm. The scale of this plot should be the same as the scale of the radar echo plot. A plot should be made every **10** minutes. All plots for these tests (e.g., observer, radar, network, system/network under test) should be based upon the same time periods (e.g., beginning on the same minute).

(ii) Weather Radar. Weather radar may be used to identify and locate thunderstorms within the area under test. The radar antenna should be **located** within 30 miles of the reference point. Level three **and greater** intensity radar echoes should, by themselves, constitute the detection of **a** thunderstorm. Level two radar echoes, when correlated with another standard observation of a thunderstorm or with a report from the sensor/ network under test, should constitute detection of a thunderstorm. However, if the sensor/network under test does not recognize a level two radar echo as a thunderstorm, and the level two echo is the only evidence of a thunder-storm, a thunderstorm should not be assumed to be present. Plots of the area under test from the radar screen should be made every **10** minutes and should depict levels two through six radar echoes. Plots should be made on a grid of approximately 3 nm squares, with the reference point **as** the center. The highest intensity level should be marked in each grid square.

(iii) ~~Thunderstorm Network(s) as a Reference Standard~~ Network(s) may be used to identify and locate thunderstorms. Thunderstorms identified and located by a thunderstorm sensor network should be plotted on a grid identical to the grid used for the radar echo plot (i.e., approximately 3 nm squares on a 30 nm radius circle, with the reference point as the center). Plots should be made of the area under test every 10 minutes.

(iv) Secondary Reference Systems. The use of secondary reference systems should be fully defined in the test plan.

(4) Execution of the Test After the FAA has approved the test plan, the manufacturer should perform the test in accordance with the test plan. All data collected during the test should be included in the test results. Any data omitted from the results should be fully explained. Thunderstorms identified and located by the thunder-storm sensor/network under test should be plotted on a grid identical to the grid used for the radar echo plot (i.e., approximately 3 nm squares on a 30 nm radius circle, with the reference point as the center). Plots should be made of the area under test every 10 minutes. The test plan should establish the criteria for the system under test, as well as all of the sensor/network standards, to be operational. As a minimum, in order for a thunderstorm day to be counted in the test results, a qualified weather observer should take observations, and the weather radar should be operational when testing.

(5) Test Report. A report should be prepared and submitted to the FAA by the AWOS manufacturer in accordance with the requirements of this AC in order to obtain certification of their AWOS with a thunderstorm detection, location, and reporting capability. Data obtained during this test should be analyzed as follows:

(i) Within 10 nm of the reference point The grid plots obtained from the sensor under test should be matched with the-grid plots obtained from the standards (qualified weather observer, the weather radar, thunderstorm sensor network, etc.), for each 10 minute increment. Thunderstorm occurrences should be matched as previously described (e.g., paragraphs 27b(3)(ii) and 27b(4)) and anomalies explained.

A. The number of test sensor/network identifications should be compared with the number of thunderstorms identified by the standards. The percentage detection accuracy should be computed and compared with the requirement in paragraph 27a(3)(i)A.

B. The number of test sensor/network identifications that are in the same or an adjacent 3 nm grid square as the thunderstorm identified by the observer/sensor/network standard should compared with the number of thunderstorms identified by the standards. The percentage location accuracy should be computed and compared with the requirement in paragraph 27a(3)(i)B.

(ii) Between 10 nm and 30 nm of the reference point The grid plots obtained from the sensor under test should be matched with the grid plots obtained from the standards (qualified weather observer, the weather radar, thunderstorm sensor network, etc.), for each lo-minute increment. Thunderstorm occurrences should be matched and anomalies explained.

A. The number of test sensor/network identifications should be compared with the number of thunderstorms identified by the standards. The percentage detection accuracy should be computed and compared with the requirement in paragraph **27b(3)(ii)A.**

B. The number of test sensor/network thunderstorm identifications should be counted that are in the same, an adjacent, or in a grid square separated by one square from the 3 nm grid square where an observer/sensor/network standard located a thunderstorm. This number should be compared with the number of thunderstorms identified by the standards. The percentage location accuracy should be computed and compared with the requirement in paragraph **27a(3)(ii)B.**

(iii) The number of thunderstorms identified by the sensor/network under test that cannot be matched with a thunderstorm identified by the standards (i.e., false signals) should be counted and compared with the total number of thunderstorms identified by the standards. The percentage of false signals should not be greater than the percentage identified in paragraph **27b(4).**

(6) **Basis of the reporting algorithm** The AWOS sensor/system should locate and report a thunderstorm within one of 10 areas of a circle with the reference point as the center and a radius of 30 nm, as follows:

Within a circle with a radius of 5 nm, with the reference point at the center.

Within the circular area between 5 nm and 10 nm from the reference point.

Within one of eight **45-degree** clockwise sectors of the circular area between 10 nm and 30 nm from the reference point, beginning with the 22.5 degree radial from the reference point.

(7) **AWOS Report of a Thunderstorm**. The AWOS voice and data report should be in accordance with the latest Government-furnished algorithm. This algorithm processes lightning strike data through a X-minute moving window, i.e., each strike is expired **15** minutes after it is received. With certain exceptions, the algorithm should report a thunderstorm when two lightning strikes have been received within the **30** mile radius circle within 15 minutes.

Within the 5 nm radius, the report is **"TSTM** at the airport."

Between 5 and 10 nm of the airport, the report is **"TSTM** in the vicinity of the airport."

Between 10 and 30 nm of the airport, the thunderstorm is reported using the appropriate sector designation. For example, "LIGHTNING NORTHEAST"; "LIGHTNING SOUTHWEST AND NORTH"; LIGHTNING EAST THROUGH SOUTH"; or "LIGHTNING ALL QUADRANTS."

When no activity is detected within the area, no report should be voiced.

If the thunderstorm sensor/system is inoperative, the message should be "THUNDERSTORM DETECTION INOPERATIVE."

28. Freezing Rain Occurrence Sensor. This sensor should be capable of detecting the occurrence of freezing rain.

a. Performance Standards Freezing rain should be reported when a minimum 0.01 inch radial thickness freezing rain has accumulated.

b. Accuracy.

(1) The sensor should correctly detect the occurrence of freezing rain 95 percent of the time.

(2) The sensor should not false alarm on frost. The sensor false alarm rate should not exceed 0.1 percent whenthere is rain at temperatures above 40°F, or when there is no precipitation. During snow, the false alarm rate should not exceed 1 percent.

c. Performance Tests The manufacturer should conduct a test program to demonstrate that the sensor meets the performance standards under the environmental conditions identified in paragraph 18. As a minimum, the following test conditions should be satisfied:

(1) Prior to testing, the AWOS manufacturer should develop and submit a test plan for approval to the FAA at the address shown at the front of this AC. The test plan should clearly outline the tests to be performed; it should define the capabilities of the sensor to be tested and should include a detailed description of the test procedures. It should contain a clear statement of pass/fail criteria. The test plan should identify the location(s) and the proposed time planned for the tests. All data collected during the test should be incorporated into the test report. Any data not included in determining the candidate sensor's compliance with the requirements of this circular should be fully explained.

(2) The test should be conducted in two phases. One phase should be conducted in a test chamber with varying conditions simulated to generate freezing rain. At least 25 freezing rain events, at various accumulation rates beginning at 0.01 inch per hour, should be simulated to demonstrate the requirements in paragraph 28b (1), and the results should be included in the test

report. Additionally, at least 10 snow events (at temperatures of 28°F or less) and 10 rain events (at temperatures of 40°F) should be conducted (at various accumulation rates) to demonstrate that the sensor does not provide false reports. (If false reports are generated during the tests, additional testing should be accomplished to demonstrate the requirements in paragraph 28b(2)).

(3) The second phase of the test should be conducted during the months of November through February at a location where there is a propensity for freezing rain and where there is a qualified weather observer on duty. The test report should compare the performance of the sensor under test with the log maintained by the official observer at the test location.

29. RUNWAY SURFACE CONDITION SENSOR. This sensor provides real-time information on runway conditions to alert the pilot if the runway is wet or if there are possible icing conditions.

a. Performance Standards. The sensor should meet the requirements found in chapter 2, paragraph 8a of AC 150/5220-13, Runway Surface Condition Sensor Specification Guide. This AC may be ordered from the Department of Transportation, Utilization and Storage, M443.2, Washington, DC 20591. The sensor should be capable of detecting three runway conditions: dry runway (no perceptible moisture), wet runway (visible moisture on the surface), and possible freezing conditions (pavement temperature below freezing and moisture present on the surface).

b. performance Test-.

(1) The testing should be performed on a sensor installed in a runway or other suitable pavement section which is free from chemicals, rubber build-up, or other contamination. The pavement temperature should be measured with an infra-red thermometer or other approved method. The sensor should be accurate within ± 1°F within the temperature band of 25° to 35°F. At least 10 observations should be made under each of the conditions in subparagraphs (i) through (iii).

(i) Dry Runway. No visible moisture is present on the sensor.

(ii) Wet Runway. The sensor is damp, wet, or flooded, and the temperature is above 32°F.

(iii) Possible Freezing Co-. The sensor is damp, wet, flooded, covered with ice, or packed snow, while the surface temperature is at or below 32°F.

(2) The sensor should be operationally tested during an entire winter season. The sensor reports should be visually verified (with consideration of the effects of wind and any chemicals on the surface) and should be accurate at

least 80 percent of the time in each of the three conditions (Le., dry, wet, and possible freezing).

30. **AWOS DATA PROCESSOR.** The four principle functions of the processor are data acceptance, data reduction, data processing, and product dissemination (digital and voice). The processor typically accepts data inputs, performs various data reduction functions, implements the AWOS algorithms, and prepares weather observation reports. The processor should have the ability to provide a computer generated voice weather observation to a ground-to-air radio (VOR, NDB, VHF discrete, etc.) for transmission to pilots. As an option, this voice message may also be provided to users via an integral automatic telephone answering device.

a. Performance=

(1) Data Reduction. The data reduction function consists of the processing of information prior to the actual algorithm processing. The AWOS data reduction software should include quality control checks to ensure that the data received is accurate and complete, and that the associated equipment is . working properly before the weather algorithms are performed. If data from any sensor is erroneous or missing (e.g., the sensor loses power, etc.), that parameter should be reported "missing" in the weather observation. The processor should continue to sample the data, and if the error condition is corrected, the weather parameter should be reinserted in the AWOS report. As an optional feature, an error indication light may be provided which should be located in an attended location and should be energized when a parameter is reported "missing" by the **AWOS**. If the examples of data reduction checks given in subparagraphs (i) through (v) are not applicable to a sensor's output, the manufacturer should propose suitable criteria. Additional criteria are encouraged.

(i) The processor should periodically check reference or calibration points within the system (e.g., reference voltage; aspirator airflow; sensor heater current, etc.) to monitor system operation.

(ii) The processor may set upper and lower limits on the sensor output which correspond to the normal operating limits of the sensor or to the real-world limits of the site. This is a gross error check that should prevent reporting clouds below ground level, negative wind speeds, etc. For example, the temperature sensor may have upper and lower limits of +130°F and -60°F.

(iii) The processor may set rate-of-change limits on the sensor's output. A rate-of-change limit might be set by determining the maximum acceptable change in temperature or signal characteristics allowable over a given period of time.

(iv) The processor may examine the history of the sensor output to detect sensor problems. As an example, the mean and standard deviation of a sensor measurement may be calculated every hour and compared to established upper

and lower limits. If the wind speed sensor has a mean greater than 3 knots but a standard deviation less than 0.5 knot, the sensor has probably malfunctioned. Likewise, the wind direction sensor is probably inoperative if the wind speed is above 5 knots and the standard deviation is less than **1** degree. Other examples of data checks include consistently low wind speeds, unvarying wind speed or direction, lack of visibility of more than 5 miles for long periods, a consistent cloud layer or a lack of clouds for long periods, and so forth.

(v) The processor should recognize continued static data output, which usually indicates a malfunction. If the sensor output is static for a sustained period of time, the parameter should be reported as missing. For example, if the anemometer output does not vary for 15 minutes, it would be assumed frozen or otherwise inoperative and wind **"missing"** would be reported.

(2) Weather Algorithms. The system processor should implement standard algorithms provided by the FAA to generate the elements of the weather observation. An observation should be generated each minute containing the current weather information for all the valid parameters observed by the AWOS. If the output is to be supplied to the National Weather Network, it should be in accordance with the appropriate Interface Control Document (ICD) (e.g., AWOS/ADAS ICD). Copies of the ICD's may be obtained from the AWOS program office at the address given in the front of the AC.

(3) System Output. The system should generate the output listed in subparagraph (i) with the other output formats being provided at the manufacturer's option.

(i) Computer-generated voice transmitted to pilots over radio (VOR, NDB, discrete frequency, etc.).

(ii) Optional telephone port for dial-up service.

(iii) Optional output port for a video display.

(iv) Optional input/output port for an operator **terminal**.

(v) Optional output port to the national weather network.

(4) Remote Maintenance Monitoring (RMM) All systems should include a dial-up input/output port that provides remote access to archived and real-time operational (i.e., weather reports) and maintenance data. This port should be used to remotely enable or disable the system, or a specific sensor(s), or to set the clock, etc. The maintenance program should be designed to utilize this RMM capability to effectively and efficiently maintain the proper operation of the AWOS. Monitoring of the system should be performed by a responsible office to regularly review and analyze the archived operational and maintenance data. The

monitor should determine that all system parameters are being correctly reported, and that the real time clock is within the specified tolerance

(5) Real-Time Clock Coordinated Universal Time (UTC) should be a product of the processor. Typically, days, hours, minutes, and seconds are provided as a system output for use in system displays, computer-generated voice output, etc. The day should be expressed in the Gregorian Calendar. Hours and minutes should be indicated numerically from 0000 to 2359. The clock function should be accurate within 15 seconds each month. For those systems whose output is provided to the national weather network, AWOS clock errors in excess of 2-minutes and 59-seconds may result in rejection of all data.

(6) Power Outage. The system should return to normal operation without human intervention after a power outage. The system should not output erroneous data when power is restored, and all weather parameters should achieve normal indications (or should indicate "missing") within 30 minutes.

(7) Data Archiving The processor should retain a record of the automated weather reports, as well as the data entered through the keyboard, for use by accident investigators. The interval between archived reports should not be more than 20 minutes, and the report should be retained for at least 96 hours (4 days) (i.e., 96 hours of data is archived on a last in, first out sequence). A method should be provided for the retrieval of archived reports using a floppy disk or other permanent record (e.g., a hard copy print out), and the operator should be able to suspend the updates of the archived weather reports to freeze the data until retrieval may be accomplished.

(8) System Constants. The following system constants should be either permanently installed in the processor at the factory or placed in a tamper-proof enclosure so that they may not be changed after initial adjustment at the site.

(i) Elevation of the pressure sensors (MSL) at the installation site.

(ii) Magnetic variation of the intended installation site to the nearest degree.

(iii) AWOS facility identification.

(iv) Algorithm constants to include the pressure reduction ratio or pressure reduction constant.

(v) Alert criteria, including site unique criteria. (This feature may be changed locally by the airport manager, or other individual responsible to airport management.)

b. Performance Testing'. System processing validation tests should be performed in three stages.

(1) A listing of digital data sets should be supplied by the FAA. This data should be input into the system processor to verify proper operation of the algorithms. Fixed and variable data sets should be provided to exercise the processor over the full range of possible sensor inputs and should include various over-range and abruptly changing data to check the data reduction quality control routines. Smaller data subsets should be run with the processing unit operating in extreme environmental conditions.

(2) Analog data sets (or digital data sets, if sensor output is digital) corresponding to the digital data in subparagraph (1) should be input at the sensor input ports to verify accurate and correct operation of the data acquisition process.

(3) Finally, a full complement of actual sensor devices should be connected to the processor (through the data collection unit if part of the design) and driven by actual or simulated weather conditions to verify accurate and correct operation of the entire AWOS unit. The sensors should have passed their individual performance/acceptance tests. Data outputs from the processor should meet the same standards of accuracy as have been established for the sensors in their individual parts of this document.

31. OPERATOR TERMINAL (OT). The OT is an optional component of the AWOS. It is normally a part of an AWOS installed at a facility with a qualified weather observer. It includes a video display terminal and keyboard, as well as a microphone, that should permit the manual addition of a voice message to the end of the computer generated voice message.

a. Performance Standards.

(1) Product Augmentation. The product augmentation function allows an authorized observer to initiate or change any observation product. A specific "editing" password should control access to this function. Manual entries of weather phenomena not automatically observed should be placed in the remarks section of the observation. In the case of a sensor failure or an incorrect AWOS output, an operator should have the capability to replace the incorrect parameter value with a missing symbol. An authorized observer should have the capability to:

(i) Prepare a "manual" observation, using the latest known weather parameters.

(ii) Manually prepare a corrected observation, either from scratch or by editing a previously disseminated product still accessible in memory.

(iii) Manually edit any observation (before release for dissemination) by override of AWOS parameters, cancellation of AWOS parameters, addition of new data, or cancellation of the entire product.

(iv) Add to the voice message. Typically, the OT should have the capability to manually input a voice message (30 seconds minimum) to the end of the computer-generated voice message when the AWOS is installed at a nontowered airport. However, when installed at a towered airport, the AWOS should have the capability to manually input a voice message (i.e., weather remarks plus NOTAM information) of at least 90 seconds duration to the end of the computer generated message.

(2) Security If an OT is a part of the AWOS system, it should be designed to prevent unauthorized persons from entering data into the system. The system should require the operator to enter a successive series of codes in response to system queries prior to allowing him/her to proceed with the entry of data.

(3) Periodic Data Validation Where an OT is used to modify the weather report, all manually entered data should be automatically time tagged by the system. The data should be valid until the next hourly or manually input observation. In order to retain the manually entered data in the system, the operator should be required to revalidate his/her "on-the-hour" observation. If no data is to be changed, the operator should be able to accomplish the revalidation using a simple procedure. The data should then be tagged with a new l-hour limit. If the AWOS is installed at a towered airport and has the capability for input of at least 90 seconds of voice to the end of the weather observation [(1) (iv)], the manually entered NOTAM information should not be automatically time tagged by the system.

b. Performance Testing. The AWOS manufacturer should test the OT to demonstrate that the unit:

(1) Displays the most current AWOS observation.

(2) Retrieves archived data.

(3) Has an editing capability, to include rejection of erroneous inputs.

(4) should provide maintenance diagnostics data and perform maintenance diagnostics, when called for in the system design.

(5) Has adequate AWOS/OT communications security.

(6) Has a'manual voice entry capability.

32. **VOICE SUBSYSTEM.** The voice subsystem should provide high quality computer-generated speech for output of the AWOS observation. A high-level error-checking scheme should be incorporated to prevent erroneous outputs. The voice subsystem should also provide the speech for the local ground-air radio broadcast and for telephone dial-up users. An optional feature is the capability for the addition of a manually input (analog) voice message from the OT at the end of the computer-generated voice message [par 31a(1)(iv)].

a. **Performance Standards.** The voice subsystem should have the following features:

(1) The voice output should be a balanced, low-impedance driver providing a minimum of one milliwatt of power into a 600-ohm line. The output amplitude should be adjustable to a nominal 0 db output or a nominal minus 13 db output.

(2) The voice message should be output continuously with approximately a 5-second delay between the completion of one message and the beginning of the next.

(3) If the voice message is in process of output when the new AWOS observation is received, the output message should be completed without interruption; voice transmission of the new AWOS observation should begin upon completion of the next delay time.

(4) The quality (clarity and phrasing) of the automated speech should provide high intelligibility when broadcasting using telephone and ground-air radio transmitters.

(5) The format and sequence of the voice message should be in accordance with Order 7110.10, Flight Services Handbook. The document may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. When any weather parameter is reported "MSG" (missing) due to a disabled or inoperative sensor, as determined by internal AWOS checks, the voice report should be "(parameter) MISSING;" e.g., "WIND SPEED MISSING;" "CLOUD HEIGHT MISSING;" etc. The UTC time of the observation should be given after the location identification.

(6) If the valid data update is not received prior to the start of the next voice transmission, the last valid data set received should be used to compose the voice message. Failure to receive a data update for more than 5 minutes should result in the termination of the voice output and generation of a failure message. In this event, the AWOS should output the message "(station identification) automated weather observing system temporarily inoperative."

(7) As an option, the voice system may contain an automatic telephone answering device that should permit user access to the voice message via the

public telephone system. The incoming call should be answered prior to completion of the second ring, and the audio signal in progress at the time the call is received should be placed on line. The voice subsystem should automatically disconnect when the weather observation has been completely transmitted twice. Typically, the telephone answering device should have the capability to answer five calls at a time with no loss of audio signal strength or intelligibility. The minimum requirement is that the system answer a single call.

(8) The voice system should contain a headset/speaker jack for monitoring the voice output.

(9) The voice quality should not be degraded when output on a VOR, NDB, or other **NAVAID**.

b. Performance Testing As a minimum, the manufacturer should demonstrate the following voice unit capabilities.

(1) A capability to generate all combinations of words corresponding to possible AWOS output reports.

(2) The ability to detect communication transmission errors, data loss, and that it should cease voice transmission after loss of updates.

(3) It should respond to dial-up requests for voice data.

(4) If the Operator Terminal is offered as an option, it should transmit manually input voice messages at the end of the **AWOS** observation.

(5) The frequency response of the computer-generated speech (i.e., voice quality) should be compatible with the frequency of the intended transmission medium (i.e., VOR, NDB, VHF radio or telephone).

33. ELECTROMAGNETIC INTERFERENCE (EMI) PROTECTION The AWOS is to be designed to minimize susceptibility to EM1 and to operate successfully in the complex electromagnetic environment of an airport.

34. TRANSIENT AND LIGHTNING PROTECTION. **AWOS** equipment should be protected against damage or operational upset due to lightning-induced surges on all sensor input lines, sensor supply lines, and incoming power and data communications lines (as well as audio and keying circuits, when transmission of the voice message is provided by other than an integral VHF transmitter). Equipment (including electrical circuits of fiber optics modems) and personnel should be protected from lightning currents and voltages, from power line transients and surges, and from other electromagnetic fields and charges. AWOS manufacturers are encouraged to design and install lightning protection systems in accordance with this AC, FAA Standards **019** (Lightning Protection, Grounding, Bonding and

Shielding Requirements for Facilities) and 020 (Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment), and the Lightning Protection Code, NFPA 78, for all equipment and structures. NFPA 78 may be obtained from the National Fire Protection Association, Inc., 470 Atlantic Avenue, Boston, MA 02210.

a. General.

(1) Cone of Protection. All equipments, including antennas, sensors, and obstruction lights that are tower mounted, should be within a maximum 45 degrees cone of protection provided by an air terminal. The air terminal should be connected to the earth electrode grounding system. The structure of steel towers may serve the function of down conductors, provided the air terminal and grounding cable connections are made as defined herein.

(2) Materials. All materials should be Underwriters Laboratory (UL) approved for the purpose used except where specific requirements or exceptions given herein apply. Down conductors should be a soft-drawn, stranded, bare copper cable weighing approximately 215 pounds per 1,000 feet. Down conductors should always be routed in a downward direction and bends should have an 8-inch or greater radius. Down conductors should be attached to the tower at approximately 3-foot intervals. Substantial electrical and mechanical connections are required between air terminals and down conductors, and between down conductors and the below grade earth electrode grounding system.

b. Earth Electrode Grounding System. New earth grounding systems should be provided and installed, or existing earth grounding systems should be upgraded as necessary. These grounding systems should consist of driven ground rods or buried plates, and buried interconnecting cables. All site grounding conductors should terminate or directly connect to the earth ground system. Adjacent earth grounding systems within 30 feet of each other should be interconnected by buried cables. The earth electrode grounding system configurations should depend upon the geological conditions at the site, with very extensive systems justifiable in areas with high soil resistivity and frequent lighting damage. Ground rods should be copper clad steel, UL approved, IO-foot minimum length, 3/4-inch minimum diameter, pointed end or coupling type, as necessary. Tops of driven rods should be at least 18 inches below grade level. Separation between rods at a site should be at least equal to their driven depth and preferably at twice their depth where space permits. Grounding plates should be 20-gauge minimum sheet copper and at least 2 feet by 2 feet in size. Grounding cables used to interconnect ground rods or plates should be bare copper of the same size as the largest down conductor required for the site. Grounding cables should be installed a minimum of 18 inches below grade level. All steel materials used to anchor guy wires should be interconnected using split bolt connectors and No. 6 AWG bare copper grounding wire. Similar bonding jumpers should be connected around guy wire couplings and fittings. Where driven poles or foundation piers are required to support towers, earth grounding cables should be installed.

c. Grounding. Grounding should be provided to conduct lightning charges, power faults, and unbalanced currents; to eliminate static and electromagnetic charges; and to provide an equal potential reference for the operation of equipments. All metallic structures, enclosures, conduit, cable armor, and conductor shielding should have a direct, identified path to the earth electrode grounding system. The grounding path should be provided by a separate grounding conductor or by bonding metallic structures or enclosures with a separate conductor to the earth electrode grounding system. All grounding conductors should be routed as directly as possible without loops, excess length, or sharp (less than 8-inch radius) bends. All equipment enclosures, housings, cases, cabinets, and racks should be grounded by an equipment grounding conductor provided and installed in accordance with the National Electric Code (NFPA-70); except that conduit and other power circuit enclosures should not be used to serve the purpose. A separate equipment grounding conductor should be provided and installed with each power circuit. The neutral conductors for power circuits should not be grounded in or by any equipment or at any point in the system, except at service entrances as defined by the National Electrical Code (NEC). At service entrances and at main disconnect circuit breaker boxes serving this purpose, the power neutral conductor and the equipment grounding conductor should be common and connected directly to the earth electrode grounding system. The grounding electrode conductor should be unspliced and routed separately without loops, excess length, or sharp (i.e., less than 8-inch radius) bends. All signals transmitted by interface lines or landlines should be balanced two-wire signal lines, or an individual ground return conductor should be routed with each signal line. A third wire may be routed with two-wire signal lines to serve as ground return or reference. The outer conductors for all coaxial, twinaxial, and triaxial cable should be grounded at equipments, antennas, and bulkheads, and not isolated at any point.

d. Bonding. Bonding is the mechanical and electrical connection of metal materials, wires, and cables for the low impedance conduction of currents and electromagnetic energy. The effectiveness of lightning protection, transient protection, grounding and shielding-depends upon the quality of bonding connections. Therefore, high quality bonding should be designed and implemented into the AWOS and its installations.

e. Shielding. Shielding should be provided to protect equipment and interface lines (all signal data, control, monitoring, power lines, and cables) from lightning currents and discharges. Shielding should also provide for the containment of interference and signals produced by equipments and to protect susceptible equipments from related environmental signals and interference.

f. Conductor Segregation, Separation, and Routing. The segregation, separation, and routing of all lines, cables, and conductors should be designed by the installer to minimize the coupling of lightning currents, transients, surges, and interference. AC power lines, signal lines, and grounding cables should be segregated and routed separately and not installed in the same trench or conduit. The parallel routing of these types of cables should be avoided and, where necessary, should conform to **NFPA-78** code. To the extent feasible, all crosses should be at right angles.

g. Transient and Surge Suppression. All transients and surge arrestors, suppressors, circuits, suppressors required at service entrances to existing buildings and shelters, and components required for the system and equipments should be furnished and installed by the manufacturer.

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